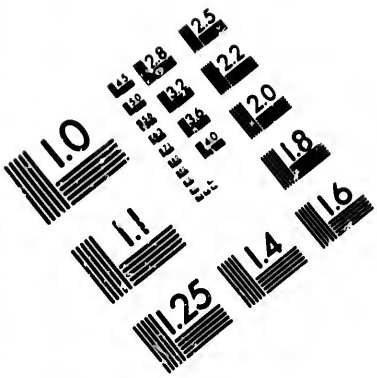

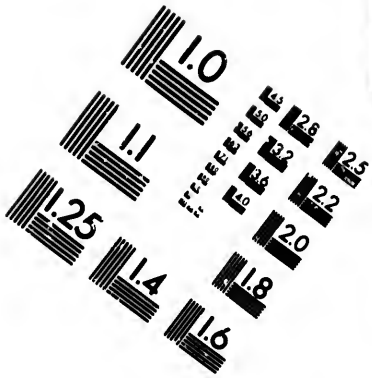

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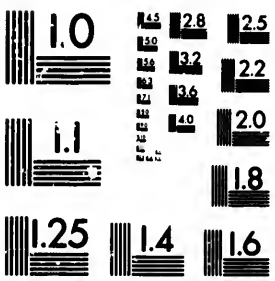

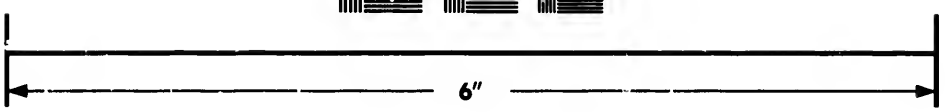

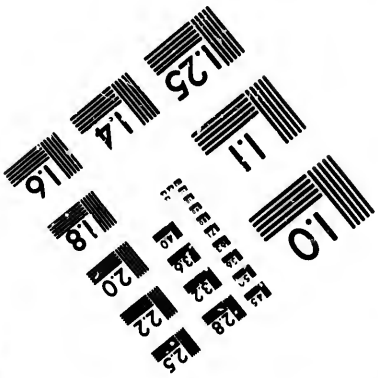

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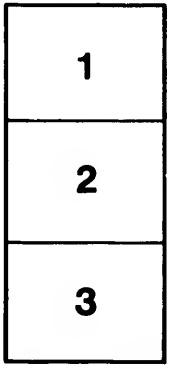

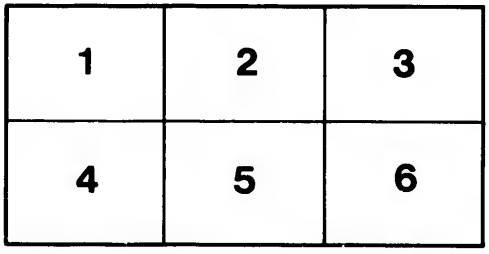

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THE DEVONIAN INSECTS OF NEW BRUNSWICK.

BY SAMUEL H. SCUDDER.

BOSTON:
PUBLISHED BY THE SOCIETY.
1880.

The Devonian Insects of New Brusnwick.

By Samuel H. Scudder.

CONTENTS.

I. Introduction.

INVESTIGATION of fossil remains of the oldest insects is nearly always extremely difficult and perplexing, and often very unsatisfactory in its results. The interest, however, necessarily attaching to the beginnings of life, warrants any labor that may be expended upon them. Especially is this true of the fragments treated of in this paper, because they are as yet the only insect remains which have been found in rocks older than the carboniferous formation in any part of the world. The writer may be pardoned for adding that they possess a special attraction for him, as among the specimens which first directed his particular attention to fossil insects, and he only regrets that so long a period as fifteen years should have elapsed before their full discussion.

The remains consist entirely of broken wings, and were discovered in 1862, by the late Professor C. F. Hartt (at the time of his death director of the geological survey of Brazil), while searching for plant remains in the devonian shales near St. John, New Brunswick. The locality — called Fern Ledges by Mr. Hartt, from the abundance of plant remains which occur in the black shales that are interstratified with the prevailing sandstones — is about a mile west of the town of Carleton, not far from St. John. The rocks form a series of ledges, exposed on the sea-shore between high and low water marks. The beds of sandstone and shale, of which they are composed, have a seaward dip of about 45°, and a strike of about W. 10° N., corresponding very nearly to the trend of the shore. The fossiliferous shales between the enclosing sandstones are worn away by the action of the water, leaving the fossils accessible in only a few places. The whole deposit is of very limited extent; it reaches along the shore for about three hundred and twenty-five paces, exposing a thickness of strata of about forty-five meters, with a width of about ninety meters.

The specimens discovered were six in number, some of them with their reverses. They are now in the museums of the natural history societies of St. John, N. B. and Boston, Mass. I am much indebted to Mr. G. F. Matthew, of the former institution, and to Professor A. Hyatt of the latter, for the opportunity of studying these specimens anew at my leisure.

The plan of the present paper will be seen by a glance at the table above. As the simpler devonian insects, first described, have certain special relations with the Ephemeridae, their description is preceded by an account of the wing structure of the modern May-flies, as a basis of comparison; each of the devonian species is then separately described, and its affinities discussed, and the whole is followed by a general summary. The stratigraphical question being, in this instance, of special importance, Principal Dawson has kindly prepared for me a statement of the case with which the article closes.[1]

II. The Structure of the wings in Ephemeridae; with a note on a Jurassic species.

The following statement considers mainly the direction and division of each of the principal veins, and the comparative areas covered by them.

The marginal vein forms the costal border. The mediastinal vein is absent or, perhaps, amalgamated with the scapular in Lachlania, Oligoneuria and Tricorythus; in all others it is simple, and extends to, or almost to, the tip of the wing, keeping at a very short and nearly uniform distance from the margin, with which it is generally connected, especially on the apical half of the wing, by frequent cross veins. On the basal half, the cross veins may be as abundant as apically, but they are generally rarer, and may be entirely absent, even when frequent apically; or they may be absent throughout. In very rare instances, as in Coloburus, an intercalary vein may be found in the apical half of the wing between this vein and the costal margin.

The scapular vein is simple, and reaches the tip of the wing, excepting in the three genera mentioned above, where it may perhaps be said to be amalgamated with the mediastinal, as shown by its forking near the middle of the wing in Tricorythus; in Lachlania, however, it terminates not at the tip, which possesses only the marginal vein, but near the middle of the costal border. It is always connected with the vein below by a greater or less number of, usually many, cross veins.

The externomedian vein is always compound, and always covers at least half, usually much the greater part of the wing. It always divides at the very base, and the upper branch is always forked, while the lower may, although rarely, remain single, and is usually forked to a less extent than the upper branch. Three is, therefore, the smallest number of nervules which may reach the margin in the area covered by

[1] Besides the references given in the bibliography under each species, notices of the devonian insects will be found in the following places: Hartt, on the Devonian plant-locality of the Fern Ledges, Lancaster, N. B., in Bailey's Observations on the Geology of Southern New Brunswick, pp. 131–40. 8vo., Fredericton, 1865; reprinted in substance, in Dawson's Acadian Geology, 2d ed., pp. 513–23. 8vo. London, 1868. Darwin, Descent of man, I, 360. 12mo., London, 1871. Stett. Ent. Zeit., XXVIII, 145–53, *passim*. Trans. Entom. Soc. Lond., 1871, 38–40. American Naturalist I, 445, 625–26. Proc. Boston Soc. Nat. Hist., X, 96, XV 150–51. Memoirs Boston Soc. Nat. Hist. III, 13–21, *passim*.

the vein, and this number we find in Oligoneuria and, perhaps, in Lachlania. The portion of the area of this vein covered by the upper branch and its forks is almost always greater, generally considerably greater, than that covered by the lower branch; an exception to this will be found in Polymitarcys where the lower area is greater, owing to unusual breadth of wing combined with narrowness of the area covered by the intermedian vein, which has been crowded out of much of its natural ground by this lower branch. Some of the allies of Polymitarcys, especially Asthenopus and Pentagenia, also have this area of the lower branch larger than usual, although not larger than that of the upper branch, and some other genera not placed near it exhibit a similar propensity; but as a general thing, the area covered by the lower is scarcely more than half as large as that covered by the upper branch, and not infrequently it is less than one third its extent. The upper branch usually forks close to the base, occasionally at the very base, and sometimes the upper of the forks is amalgamated at the base with the scapular vein, as in Asthenopus, Tricorythus and Chloeon, and to a certain extent in Coenis, so as to give it the appearance of originating from that vein, and of complete independence of the externomedian; whether thus severed from its connections, or plainly arising from the externomedian root, this upper fork of the upper branch runs in proximity to the scapular vein, parallel or subparallel to it, and, excepting where the venation is occasionally simple (as in Oligoneuria, &c.), always emits from its lower surface in the central portion of the wing one, two, or three nervules; the first and second of these nervules are usually pretty near together at base, but all generally reach the border at unequal distances apart, the inequality being made good by intercalary longitudinal nervules; these intercalary nervules often curve at their inner extremities toward or to one or another of the adjoining nervules, assuming then the appearance of regular branches, while the nervules proper are themselves oftener detached from their base; so that it is sometimes difficult to tell whether a given vein should be considered normal or intercalary. The lower fork of the upper branch is occasionally simple, as in the Tricorythus, but usually forks once at about the middle of its course, rarely near the base, and very frequently encloses an intercalary nervule between these branches, but no intercalary nervules (excepting such as often break up the extreme margin into an irregular meshwork of veins) ever intervene between the upper nervule of this fork and the lower nervule of the upper fork, nor between its lower nervule and the upper nervule of the lower branch of the externomedian vein, excepting in the rare instances where this lower nervule is detached from its base, and takes on the form of an intercalary nervule.

This lower branch, as has been said, is usually forked to a less extent than the upper branch, but a conspicuous exception is found in Polymitarcys where the branch is made up of a large number of sub-convergent simple rays, directed from the outer margin toward various parts of the upper internomedian nervule, but generally lost before reaching it. In general, however, its area is only about half that of the upper branch; it usually forks close to the base, and each or either of its branches may again subdivide once; all other nervules in the area are sure to be intercalary; where it forks only once there is usually a single intercalary nervure midway between the branches, which seems to belong to one or the other of them and to represent its fork; while between it and either branch there

may be other shorter intercalaries; the only exception to this general statement is the case of Polymitarcys already cited, where after division at the base the upper fork must be looked upon as breaking up at once into three rays, while the lower severed from its connections breaks up similarly into a couple of forked rays; the amount of abnormal divergence in this case may be better seen, by stating that it is the only genus of Ephemeridæ in which this area is carried around the lower outer angle of the wing; in all others it stops short of, usually far short of this angle; here it reaches around it half way along the anal margin. The genus agrees, however, with all the others in that all the branching occurs in the basal half of the area. In Oligoneuria and Lachlania the branch is simple and undivided, unless the apparent branch in the latter should be looked upon as such, and not as a cross nervure, like the more directly transverse veins above it.

The area of the internomedian vein is never great, although always more extensive than that of any other vein but the externomedian, and it always includes the lower outer angle of the wing, excepting as above specified in Polymitarcys, and excepting also in the full-angled Tricorythus, where the anal area disputes its sway. Its construction is generally similar to that of the lower branch of the externomedian vein, although from the form of the area covered by it, its absolute appearance is very different; moreover, one rarely finds in it any intercalary nervures, excepting such as sometimes line the extreme border, the smaller nervures almost always originating from the main stems; the exceptions are found in Leptophlebia, Cloeon, and Baetis. The vein almost invariably forks at its extreme base, and from the upper of these branches sends either, rarely, a single shoot, or, much more frequently, a half a dozen, occasionally a dozen simple or forked shoots to the margin. In the interesting fossil described in the note at the end of this section these shoots appear to originate from the lower branch, the upper remaining simple, just as rarely occurs in living forms as *e. g.*, in some species of Leptophlebia.

The anal vein invariably plays an insignificant part, and is apparently sometimes wanting. Its area seldom reaches even half way along the anal margin, but in Tricorythus it extends even around the lower outer angle, fairly upon the outer margin. Here it is composed of a single vein with three or four short but widely divergent branches; usually it is forked at the base, and occasionally one or the other of these forks imitates the rayed branch of the internomedian by sending a number of parallel branches, often closely crowded, to the margin.

This account of the neuration of the Ephemeridae is based upon much more extended material, and a longer study than that formerly given by me in my first quarto paper on fossil neuroptera, and corrects it in several important particulars, especially in the account of the internomedian vein, which was eroneously stated to be simple[1] and in the fuller statement of the divisions of the externomedian vein.

Note on a Jurassic May-fly.

Hexagenites Weyenberghii, gen. et sp. nov.:—A fragment of a wing only is preserved, in which the entire costal area and base are wanting. The neuration of the parts that remain

[1] This statement was evidently the result of some oversight, since in the digest given on a subsequent page of the same memoir it was remarked that the internomedian vein was "similar in character to the *vena externomedia*."

is perfect and indicate an insect whose alar expanse was nearly 45 mm., and which is most nearly related to Hexagenia; the first inferior nervule of the upper fork of the upper branch of the extermomedian vein is thrown off some way before the middle of the wing; the lower branch forks at some distance beyond the middle of its course, and encloses between its branches a single intercalary nervule which extends nearly to the widely spreading fork. At a short distance from the base of the wing the lower branch of the externomedian vein has divided into three branches, the middle one nearer the upper than the lower, all of which continue undivided to the margin; two intercalary nervures of unequal length occur in each of these interspaces, extending almost half way to the base in the lower interspace, besides many short ones near the margin; the lowest of these branches is considerably curved and subparallel to the inner margin. The internomedian vein probably divides at the very base into two branches, the upper of which is simple, runs subparallel to the lowest externomedian nervule, striking the angle of the wing, while the other branch is in close proximity to it and throws off a large number of sinuous simple branches to the anal margin, in doing which its outer half follows an irregular course by a slight change of direction with each emission. The cross-veins are moderately frequent and subuniform throughout the portion of the wing which is preserved excepting in the internomedian area, and the border is much broken by intercalary nervules into cells which are quadrate and generally much longer than broad. The anal area must be very contracted and the form of the wing closely resembles that of Hexagenia.

The specimen is from Solenhofen, and is in the British Museum. The description is drawn up from a very clear sketch magnified 7 diameters, taken with the camera and published by Rev. Mr. Eaton in the Transactions of the Entomological Society of London, 1871. Pl. 1, fig. 10. The species is dedicated to my friend Dr. Weyenbergh, of Cordoba, who has done so much in increasing our knowledge of the Jurassic insect fauna of Bavaria.

III. Platephemera antiqua. Pl. 1, figs. 5, 9, 10.

Platephemera antiqua Scudd., Can. nat., (n. s.) III, 205, fig. 2 (1867);—Ib.; Geol. mag., IV, 387, pl. 17, fig. 2 (1867); — Ib., Dawson, Acad. Geol., 2d ed., 524, fig. 181 (1868); — Ib., Amer. nat., I, 630, pl. 16, fig. 3 (1868); — Ib., Geol. mag., V, 173, 175–76 (1868); — Pack., Guide ins., 77–78, pl. 1, fig. 3 (1869); — Nichols., Man. pal., 185, fig. 128 (1872); — Ib., Anc. life hist. earth, 145, fig. 89 (1877); — Dana, Man. geol., 2d ed., 273, fig. 550 A (1874); — Roem., Leth. geogn., pl. 31, fig. 9 (1876).

Mentioned without name, as the first species, in my letter to Mr. Hartt on the Devonian Insects of New Brunswick (1865); — Bailey, Obs. geol. south. New Brunsw., 140 (1865); — Amer. journ. sc., (2) XXXIX, 357 (1865); — Can. nat., (n. s.) II, 23 (1865); — Trans. entom. soc. Lond., (3) II, 117 (1865). See also Amer. journ. sc., (2) XL, 277 (1865).

The wing was ample (whence the generic name) and gigantic. Probably a third of the wing is wanting at the base, besides the greater part of the extreme outer edge, but the fragment preserved enables us to judge, probably with considerable accuracy, both the general structure and, by the direction of the nervules and of the margins, the general

form of the wing, which is presumed to be much as outlined on the plate. The wing was probably more than 60 mm. in length, and about 27 mm. in breadth; the alar expanse was therefore at least 125 mm., and probably 135 mm., and the two figures have been so placed as to indicate this expanse.

This is more than double the ordinary size of the larger Ephemeridae and the largest mentioned in Eaton's paper on these insects has an expanse of only 78 mm., and the largest of the jurassic species only 65 mm.

The costal margin is very gently arcuate; the apex probably somewhat pointed, toward which the upper veins are directed without additional arcuation; the greatest breadth was probably a little before the middle of the wing, and the outer perhaps half as long again as the anal margin. The marginal vein runs close to but does not form the margin of the wing, the latter being indicated in the figures on the plate by a dotted line.

The mediastinal vein runs as close as possible to the margin, and is not connected with it by cross veins; these two veins apparently run side by side to the apex, when the marginal disappears and the mediastinal takes its place close to the border. The scapular vein runs sub-parallel to the mediastinal, but at double the distance from it apically as basally, the change occurring rather abruptly near the middle of the preserved portion of the wing; it is connected with the vein above by straight cross-veins at tolerably regular, rather frequent intervals.

As usual in this family, the externomedian vein is apparently divided, probably not far from, or at the base, into two stems, and the upper of these stems is again divided, probably at some distance from the base, into two principal branches; the main portion of the upper branch runs parallel to, but somewhat distant from the scapular vein, approaching it, however, apically, and is everywhere connected with it by cross-veins, very much as in the mediastino-scapular interspace; it throws off from its inferior surface several inequidistant feeble offshoots; the first originate a little before the middle of the wing, and run irregularly but with a gentle downward curve to the outer margin; they have between them and between the outermost and the main branch a number of equally irregular intercalary nervules, all of which are connected together by cross-veins, and thus form over the whole area a mesh work of irregular but usually hexagonal and longitudinally elongated cells, making it impossible to distinguish between normal and intercalary veins, since the latter are as prominent as the former, and invariably arise from cross-veins; while whatever nervules lie next the main branch are united with it by frequent and, equally irregular cross-veins falling from the main branch quite in the manner of the offshoots proper, and forming cells only slightly larger than the others, although generally transversely elongated; together there are about nine rows of cells between the main upper branch and its first offshoot. The lower branch of the upper stem is simple and, originating apparently near the middle of the basal half of the wing, diverges at first slightly from the upper branch, afterwards a little more rapidly, and in its apical fourth curves downward considerably, and is somewhat irregular in its course; its direction is in general parallel to the offshoots, and especially the nearer offshoots of the upper branch, and on the border it is separated from the apex of the upper branch by nearly one-third of the outer margin of the wing; in its simplicity this branch resembles the same nervure in Tricorythus, which is peculiar in this particular among modern Ephemeridae. As in

modern Ephemeridæ generally, there is no intercalary nervule between this lower branch of the upper externomedian stem and the first offshoot of the lower branch, but this interspace is filled with simple and frequent cross veins.

The lower externomedian stem is apparently formed on the same plan as the upper, a feature which appears to have no counterpart among living Ephemeridae; apparently it is composed, like the upper, of two primary branches, which seem to part from each other very nearly at the same considerable distance from the base, (about one-third the distance to the margin), a feature uncommon but not unknown in living Ephemeridae; but instead of having a single independent intercalary or two between the forks, it has several offshoots which depend from the upper branch, just as the offshoots of the upper branch of the upper stem do, while between them in the outer half of their course other intercalaries arise, depending from angular cross veins — the whole united by frequent cross veins (again as in the upper area), to form a mesh-work of irregular cells generally pentagonal, although not often longitudinal; there are thus included between these forks about six rows of cells. The interspaces directly adjoining either side of the lower branch of the upper externomedian stem are slightly wider than the interspaces between the nervules in the area of the lower externomedian stem, possess no intercalaries, and are divided by frequent cross veins. The lower branch of the lower externomedian stem also curves downward at the tip, like the lower branch of the upper stem; the area of the lower externomedian stem repeats, therefore, and on only a little smaller scale, the structure of the area of the upper stem, instead of exhibiting, as in recent forms, distinctive features.

That portion of the fragment of the wing lying below what we have here considered the lower simple branch of the lower externomedian stem, and which is shown in fig. 10 and not in fig. 9, is so fragmentary and so separated from its basal connections that it is difficult to decide to what area of the wing it belongs; it consists of four rows of cells separated by curving nervules a little more uniform in their course than the minor nervules above, with slightly less frequent cross veins; the cells being slightly larger and more regular, frequently quadrangular and usually longitudinal; this field belongs of course either to the externomedian or the internomedian area. The general similarity of the structure of the fields would lead one at first to suppose it to belong to the externomedian area, in which case of course our description of the lower stem and its branches should be modified to receive it. As, too, the form of the fragment would indicate that a very considerable part of the region about the anal angle is lost, the reference of this field to the internomedian area would give that area a very great and very unusual preponderance in the wing. But its reference to the externomedian area, which is certainly possible, would involve quite as great an anomaly; for in that case the lower externomedian stem must be supposed to consist of two branches, the lower lying beyond the present fragment and probably simple, the upper forked and reproducing on a smaller scale the whole of the upper externomedian stem, including the minor offshoots depending from the uppermost branch of each. In this case the area of the lower stem would exceed that of the upper, which occurs in very rare instances in modern Ephemeridae and then only by crowding out of room the lower areas, which the probable wide expanse of this wing would not allow unless this lower area is of an exceedingly disproportionate size. The translation of the facts which I have offered in my description, on the other hand, while it

requires a very unusual development of the internomedian area, leaves the lower externomedian field in its usual proportionate extent as compared to the upper field, and is further supported by several considerations: chiefly by the probability that where repetitions of structure are found — a mark of simplicity much more common among ancient than among recent insects — they are far more apt to occur between repetitive parts than between those which may not be so exactly compared. On the hypothesis sustained above, this repetition occurs in the fields embraced between the two similarly disposed sets of branches into which one vein is divided. On the other suggested (and apparently the only alternative, for the open interspaces on either side of the lower branch of the upper externomedian stem seem to fix that nervule unquestionably) the repetition would be between the whole of one set of branches of this vein, and one portion only of the two of which the other set of that vein is composed. Other arguments may be advanced from the character both of the nervules and of the cells formed by them and the cross veins, which differ slightly from those in the field next above, a difference greater both in extent and in nature than that existing between what we have considered the upper and the lower externomedian fields. Further than this, the slight change of direction in the course of the outer margin, resulting in a slight emargination of this border of the wing, although apparently not found at all in living Ephemeridae, would be far more likely to occur, does far more frequently occur in other insects, between two adjoining areas than in the middle or other part of one.

Considering then the field under discussion as belonging to the internomedian area, we must describe this as plainly of very unusual extent, and as filled as it never is in living types with a large number of intercalary nervules.

It may be remarked that none of the many intercalaries in this wing arise independently, and that they are not more abundant at the extreme outer edge of the wing, as is frequently the case in modern types. The former feature is the more noteworthy, as the independent origin of the intercalary veins in Ephemeridae would naturally be taken as a mark of inferior organization; and yet it does not occur in this oldest member of the group, nor yet in the jurassic species from Solenhofen, described on a previous page; in this last, however, the edge of the wing is more broken by intercalaries than the parts removed from it.

The length of the fragment preserved is 42 mm. and its greatest breadth, 25.5 mm.

The points in which this insect presents the most striking differences from modern types, and upon which we would establish the genus Platephemera, are: the very similar instead of distinctive structure of the framework of the two sets of branches of the externomedian vein, and of the respective areas included between them; the excessive number of the intercalaries in the area included between the lower set of externomedian branches, and their attachment (in the apical half of the wing) to the upper of these branches — from which the previously mentioned peculiar feature mainly depends; the simplicity of the lower branch of the upper externomedian stem in an unusually ramose wing; the unusual extent of the internomedian area and its rich supply of intercalaries; the density and polygonal form of the cells formed by the cross veins below the upper externomedian vein; the emargination of the outer border; and finally the vast dimensions of the wing.

If we look to other early types for species akin to this we shall find a whole group of carboniferous insects with reticulated wings, to which this is evidently related. To this belong those forms to which the generic names Dictyoneura and Breyeria have been given in the old world, and Paolia and Haplophlebium in the new. Several new forms, as yet unpublished, are known to me from the American carboniferous rocks. In all these genera, but especially in Dictyoneura and Haplophlebium (which perhaps should not be separated from each other), the wing is very much larger and slenderer (like a dragon-fly's wing) than the fragment of this devonian wing will allow us to suppose it to be. As in these wings, the mediastinal vein is present, and usually runs into the marginal at some distance from the tip of the wing, and the general relation of the principal veins is similar in all; in none of the others, however, do we find so distinct a meshwork of subordinate veins, nor can they be resolved as here into sets depending from the two principal branches of the externomedian vein. So that while a general similarity of structure may be conceded, there is no occasion for considering the insects as closely affiliated.

The distinction between Platephemera and Gerephemera will be pointed out in treating of the latter insect.

This insect came from plant-bed No. 7 of Professor Hartt, and was the only insect found at that horizon.

In his "Monograph on the Ephemeridae,"[1] Rev. Mr. Eaton treats of the fossil species which have been referred by one and another author to this family, in a very summary manner,[2] asserting that: "when a fossil comprises only a fragment, or even a complete wing of an Ephemerid, it is hardly possible to determine the *genus*, and impossible to assert the *species*. The utmost that can be learned from such a specimen is the approximate relations of the insect. Neuration by itself is not sufficient to define the species or even the genera of recent Ephemeridae."

While we should not wish to deny the claims of Mr. Eaton to a profound knowledge of the structure of the Ephemeridae, we venture to doubt if he would assert that there are not features in the wing structure of some genera not found in others, and which are, therefore, in so far characteristic of those genera; and it might be worth while to consider whether a careful study of such differences would not reveal some further differences not discernible upon a cursory examination. One should be slow to hazard sweeping statements of a negative character; and after all, it may be enquired, what more is desired, or at least expected, than "the approximate relations of an insect" found fossil in the older rocks. That is precisely the aim of palaeontology the world over; and those who discourage efforts to discover these relations are simply bidding us close one of the volumes of the book of life, quite as valuable as that they study.

In further comments in the same place, Mr. Eaton asserts of the insects of the Devonian discussed in this paper, that "they have all been regarded as allies of the Ephemer-

[1] Trans. Entom. Soc. Lond., 1871, 38–40.

[2] The manner in which Mr. Eaton has confounded names in this section of his work is pretty fair evidence that he has not given the papers he quotes that close attention which would entitle him to use the language of ridicule toward their authors. In the three pages he devotes to this topic, Dyscritus is twice given as "Dyscritius"; articulatus twice as "antiquorum"; occidentalis once as "Brownsoni"; Bronsoni twice as "Brownsoni"; Dana twice as "Scudder"; Scudder six times as "Dawson."

idae." I do not know by whom; certainly not by myself, who first described them. Platephemera he says, may possibly belong to the Ephemeridae, "but there is nothing in the figures to make this certain." The better figures published with this should be sufficient proof that Platephemera belongs where I originally placed it. The neuration agrees in all essential features with that family, and indeed, considering the antiquity of the creature, shows marvellously little divergence from existing types. And although Mr. Eaton has nothing to say of the wing structure of the Ephemeridae as a whole, in distinction from that of other neuropterous families, I can hardly believe that any one who has studied it from the standpoint of the substantial unity of wing structure in all insects, could fail to discover that the Ephemeridae have a special development of wing neuration distinct from all others, permitting formulation, and to which Platephemera conforms to so close an extent, that until we have further light by the discovery of more complete remains we are amply justified in considering it as an antique type of Ephemeridae.

IV. Gerephemera simplex. Pl. 1, figs. 8, 8a.

Gerephemera simplex Scudd., Geol. mag., v, 174–75 (1868).

Mentioned without name, as the fourth species, in my letter to Mr. Hartt: On the devonian insects of New Brunswick, p. 1; Bailey, Obs. geol. south. New Br., 140; Amer. journ. sc., (2) xxxix, 357; Can. nat., (n. s.) ii, 235; Trans. Ent. Soc. Lond., (3) ii, 117—all in 1865.

In the specimen and reverse as first seen by me, scarcely more could be said of this insect than the brief notice already published; nothing appeared but a slight fragment of the tip of a wing, and this would not have been dignified by a name had not the extreme interest attaching to fossil insects from the horizon at which it occurred seemed to demand it. The portion preserved was the upper half of the outer border with the extremities of the veins impinging upon it, and two of the principal veins near the tip of the costal margin; these two veins are as usual in the Ephemeridae and probably represent the marginal and mediastinal (or scapular), and show that the latter reached the border scarcely above the tip of the wing.

Since my first examination, however, Mr. G. F. Matthew has worked out a considerable part of the wing on one of the stones belonging to the St. John Society, which, though very different in certain parts from what would have been anticipated from the portion first exposed, bears out in a measure the statement that was hazarded concerning it, although it proves that the generic name chosen was unfortunate. In this removal of the stone from the surface of the wing, a fragment of the tip with its two veins was flaked off; but as careful drawings had been taken of it, I have replaced the two lines indicating the veins mentioned above upon the drawing made of the wing as it now appears. This gives us indeed a much better clue to the probable form of the wing than we could possibly otherwise have, for the considerable and constantly increasing divergence of the upper and lower veins of the continuous portion of the fragment leave a very strange effect; and, without the aid these two vein-tips furnish, leave the form of the apex of the wing decidedly problematical.

The wing is that of a very large insect, the fragment, which reaches neither base nor tip, being 60 mm. long, and rendering it probable that the alar expanse was at least 150 mm. and more probably 175 mm. The apex of the wing was pointed, the costal and outer margin probably meeting at a rounded angle of about 60°. The costal margin must have been very strongly arched near the middle of the apical half, while the apical part of the outer border is nearly straight. The wing was probably elongated, not very broadly expanded in proportion to its length, as I at first presumed from not having counted on such an extended development toward the base. In the middle of the outer half of the wing the width is about 23 mm., and from the course of the fragments of the two borders it is probable that the width nowhere exceeded 25 mm. or about two-sevenths the length of the wing. The fragment preserved contains considerably less than half the area of the wing comprising most of the central portions. The whole anal area is lost as well as what is apparently most or all of the internomedian area, extending far along the outer margin; the merest fragment of the costal border, 2–3 mm. long, is preserved, apparently about the middle of the wing; the tip of the wing and outer half of the costal margin are broken away, but a couple of veins at the tip are supplied, as already stated, from a piece that was accidentally removed. This irregular fragment, extending diagonally across the outer half of the wing, with a basal extension along the middle line, is traversed by principal nervures bound together by a net work of mostly very irregular and very feeble, occasionally more regular and distinct cross veins, forming irregular, mostly longitudinal, unequal, polygonal, rarely quadrangular cells. The veins may be grouped into an upper set of parallel, equidistant and rather approximate, nearly straight, slightly upcurved nervures, three or four in number, traceable only near the middle of the wing; and a lower set of two, traceable throughout the apical half of the wing and extending nearly half way from the middle to the base; these are parallel, more distant, directed gently downward and so divergent from the other set, and toward the apex curved considerably downward Between the veins of the upper set the cross veins are infrequent and mostly straight, forming quadrangular cells; while in the lower set they are more frequent and very irregular, forming polygonal cells which, toward the apical margin, are very indistinct from the feebleness of the cross veins.

The area formed at the apex of the wings by the divergence of the two sets of veins, is filled by branches from the *superior* surface of the uppermost of the lower set of veins, supporting a mesh of cross-veins.

The principal vein of the wing then—the only one which appears unquestionably to support a number of branches — is the uppermost vein of the lower set. And since in all palaeozoic insects having true net-veined wings, one never has to pass beyond the externomedian vein, in starting from the costal margin, to find the first extensively branched vein, there can be little if any doubt that this should be considered as belonging to that vein, and not to a lower one. The only difficulty about this interpretation is that in the middle of the wing, there are above this vein no less than five equidistant and almost equally distinct veins. The first of these, forming the margin, is the marginal vein, and the next is the mediastinal. It is impossible to consider this marginal as the mere thickening of the border, and the vein next removed from the border as the true marginal vein, for both the margin itself would be too broad, and the marginal would

then be an elevated, and the mediastinal a depressed vein (see fig. 8a), which is never the case in such insects. The nervure at the margin then is certainly the marginal, and that next to it the mediastinal vein. Only one vein, the scapular, can lie between the mediastinal and the externomedian, yet between our undoubted mediastinal and our presumed externomedian there are no less than three veins to be disposed of.

Two of these lie in the depression following the mediastinal vein, while the third is upon the side or the upper edge of the ascending portion of the area, which on the opposite side of the depression lies at the level or above the level of the mediastinal vein (see fig. 8a). It seems, therefore, highly probable that the two low-lying veins are branches of a scapular vein which probably divides not much further toward the base; and that the third vein in question is the main externomedian stem, of which the branching vein below is only a principal basal offshoot; indeed the very fact that the branches of this offshoot are thrown off from its *superior* surface leads to the presumption that it is itself a branch from a vein above; for, while an area between two branches of one vein may not very infrequently be filled by superior offshoots from an inferior branch, it would certainly be abnormal for a wide area to be filled by superior offshoots from an upper branch, or even from a main stem itself. Presuming then upon the correctness of these interpretations, the structural basis of the wing is as follows:

The marginal vein forms the border. The mediastinal vein is simple, and, running nearly parallel to the marginal vein, probably terminates by impinging upon it not very far from the middle of the outer half of the wing; from it run frequent oblique delicate cross veins to the border. The scapular vein divides into two longitudinal veins before the middle of the wing, probably considerably before it; for even before the middle of the wing, and for as great a distance beyond it as it can be traced, the two branches are exactly parallel to each other and the mediastinal; all the longitudinal interspaces in the middle of this part of the wing are equal; the forks are connected with each other (and the upper with the mediastinal?) by tolerably frequent faint cross veins at right angles to the nervures; and in the middle of the wing and beyond it, at least for a short distance, have a gentle upward direction, and even curve very slightly, almost imperceptibly, in the same direction; beyond however, they must curve strongly in the opposite direction, for the pair of detached veins toward the tip of the wing have a decided downward direction, and these forks, whether the same or not, must in that part of the wing have a similar direction; probably they are the same, and if so they show that they retain a similar distance apart until they strike the costal margin, one just before or at the tip, the other a little earlier.

The externomedian vein must divide into two principal veins near the base of the wing; the upper branch follows closely the course of the veins above, and lies as far from the nearest as the latter from the next; a little beyond the middle of the wing, however, this space is slightly increased, and an intercalary vein, straight and similar to the others, but fainter, takes its rise from an oblique bent cross vein; all the other cross veins in this interspace and on either side of the intercalary vein, are like the others in the scapular interspaces, and the whole area in which these straight and directly transverse cross veins lie, namely that between the mediastinal and upper externomedian veins, forms a deeply sunken but broad sulcus, the floor of which is nearly flat, and not V-shaped as usual in folds in this

part of the wing; probably it is otherwise further toward the base of the wing before the division of the scapular vein, for the sides of the sulcus are tolerably steep, and where only a simple vein occupied the sulcus, as is ordinarily the case in neuropterous wings, the sulcus would be angular. The lower externomedian branch at the middle of the wing is already as far from the upper branch as that from the upper scapular branch, and continues to diverge from it with a very gentle curve, which increases apically, so that it strikes the border with the same direction as the veins above; in the interspace between these two branches runs a feeble intercalary vein, slightly irregular in direction, sending off cross veins to one side and the other, forming longitudinal irregularly pentagonal cells; as the interspace widens these become more irregular, until at about two-thirds the distance from the base of the wing to the tip of this branch, a superior offshoot from this branch is emitted, having a course about midway between the two branches, but very soon taking a somewhat zigzag direction, and assuming altogether the appearance of the intercalary, to which it sends frequent cross veins; a short distance further on, or at about the end of the second third of the wing, this emits a second offshoot, rather more prominent and regular than the first, which parts rapidly from the branch, and, remaining near the first, afterwards takes the apical direction of all the veins; it is bound to the upper offshoot by frequent cross veins forming small polygonal cells; between it and the lower externomedian vein is another very feeble intercalary arising from a cross vein, and becoming, like its lateral offshoots, nearly imperceptible toward the outer margin; as indeed do all the other cross veins and intercalaries, so that they were nearly unobserved when the margin alone was exposed, and many of the cross veins fail to compass the interspaces.

What can be seen of the internomedian vein is traceable slightly further toward the base of the wing than the preceding, but as the wing is broken here, it is impossible to say whether it is basally divided, and the portion visible is the upper branch, or whether what we see is the whole vein; in the former case the upper branch, in the latter the vein proper, runs sub-parallel to the lower externomedian, very slightly diverging from it, and in the middle of the wing (where it is broken, but where its connections leave no doubt whatever of its course) is as distant from it as the two externomedian branches at the same point; a single, distinct, pretty regularly zigzag intercalary runs midway between it and the lower externomedian branch, connected with tolerable regularity to the veins on either side by alternating, straight, transverse or oblique cross veins, generally forming rather regular, longitudinal, pentagonal cells, which become exceedingly irregular, obscure and broken next the outer margin of the wing; just below the apical offshoot of the lower externomedian branch it throws off an inferior branch, which is nearly straight, and is apically as distant from it as is the next vein above; between these branches is a very irregular intercalary vein, resembling in its connections the apical part of the intercalary above. The parts of the wing below this branch are wanting.

The relations of this insect to living types is far more obscure than in the case of Platephemera. It has certain resemblances to Platephemera and also to the carboniferous Palaeodictyoptera to which it may possibly belong, but it is certain that the limits of the Ephemeridae, even including Platephemera, are not elastic enough to admit it, and its divergence from Dictyoneura and other net-veined insects of early time is so great that its

reference there would seem to obscure its real isolation. In fact there seems to be not only no family of insects into which it can be placed, but even no sub-order living or extinct, into which it would naturally fall. There is no known insect in which five parallel and distant nervures follow the course of the costal margin, and of which only two arise from the same root; and so far as my observations have gone, I have found no neuropterous insect (to which of living groups this is plainly the most nearly allied), in which the externomedian vein is the first extensively branched vein, and in which at the same time, the upper branch of this vein is simple. In Ephemeridae (to which group one would most naturally compare it from its general appearance), the externomedian vein, as already stated, is always compound, and its upper stem is always forked. In this insect on the contrary, the upper stem is simple (which is the more remarkable from the forked character of the scapular, always simple in Ephemeridae) and the lower forked, its branches being superior and herein differing remarkably from ordinary types.

Gerephemera then is not only further removed from modern Ephemeridae than is Platephemera, but can be even less closely affiliated with Platephemera than the latter with modern Ephemeridae. It has, nevertheless, some distinctive points in common with it. Such are its great size and the probable great expanse of the internomedian area, the differing character of the net-work above and below the uppermost externomedian branch, the polygonal nature of the mesh-work caused by the cross-venation (in common with many other old insects), and the somewhat uniform character of that network next to and away from the border. In common with modern Ephemeridae, but in distinction from most other insects, must be mentioned the common feature of intercalary nervures, which here, as in Platephemera, are never free at their origin.

As points of special distinction from Platephemera may be mentioned the broad area given to the veins above the externomedian vein, the forking of the scapular vein, its course at the bottom of a deep and broad sulcus, the occurrence of a straight intercalary in the scapular-externomedian interspace, the entire structure of the externomedian vein (differing altogether from Platephemera) and the elongated slender form of the wing, which resembles much more closely Dictyoneura and Haplophlebium.

From these latter genera again, to which we should perhaps consider it most closely allied, this insect differs remarkably in the structure not only of the externomedian vein, but in the wide extent of the wings above that vein, and the number of nervures which fill it. It would appear also to differ in the character of the reticulation above the externomedian vein, a matter of less importance, but in which it agrees with Platephemera. The difference in the frame work of the wing, however, is so great and so deep seated, that there can be no doubt of at least its family distinction from all known types. Whether or no it is worthy of being classed as subordinally distinct, I leave to future discussion. But in allusion to the apparent fact that the peculiar nature of its neuration has not left its mark on modern types, I propose to call the family group in which it should be placed Atocina.[1] It will be sufficiently distinguished from other ancient types (as from modern) by the forking of the scapular vein, the course of the externomedian, its distant removal from the costal margin, and its peculiar division.

This insect and Xenoneura come from the lowest of the Lancaster Shales which furnish insect remains, called plant bed No. 2, by Professor Hartt.

[1] From the Greek ἄτοκος.

V. Homothetus fossilis. Pl. 1, figs. 1, 2.

Homothetus fossilis Scudd., Can. nat. geol., (n. s.) III, 205, fig. 3 (1867); — Ib., Geol. mag., IV, 387, pl. 17, fig. 3 (1867); — Ib., Daws., Acad. geol., 2d ed. 524–25, fig. 182 (1868); — Ib., Amer. nat., I, 631, pl. 16, fig. 7 (1868); — Ib., Geol. mag., V, 172, 176 (1868); — Pack., Guide ins., 77–78, pl. 1, fig. 7 (1869).

Mentioned without name, as the second species, in my letter to Mr. Hartt: On the devonian insects of New Brunswick, p. 1; Bailey, Obs. south. New Br., 140; Amer. journ. sc., (2) xxxix, 357; Can. nat. geol., (n. s.) II, 235; Trans. ent. soc. Lond., (3) II, 117,—all in 1865.

The wing representing this insect is the most complete of the devonian insects, and would leave little to be desired were the base more complete; unfortunately the reverse of this specimen was never found, or it might supply the missing parts. To judge from the strong convexity of the costal margin, it is a front wing. It has the general appearance of a Sialid of moderate size, and the form of the wing closely corresponds. Although a fragment from the middle of the costal margin, and the whole outer half of the lower margin with the apex are missing, the form of the wing can be estimated with considerable probability. The costal margin is in general strongly convex, but is flat in the middle third, the basal portion rapidly ascending, and the apical as rapidly descending; the apex was probably rounded but a little produced, and the hinder border pretty uniformly and fully rounded, making the middle the broadest part of the wing, where the breadth is probably contained about three times in the length; toward the base the wing narrows rapidly, but at the extreme base more gradually above so as to be almost pedunculate.

The marginal vein forms the border. The mediastinal vein is at first inclined slightly downward, then ascends as gently, parting slightly from the marginal, but again in the middle of the wing commences most gradually to approach it, running toward the extremity of the wing in close contact with it, but apparently not joining it until just before the apex and beyond the preserved part of the fossil; throughout it partakes of the course of the margin, but in a less exaggerated form, ascending slightly beyond the basal part, then straight in the middle, gently arcuate apically; it is connected with the margin, so far as can be made out, by a single straight cross vein somewhat before the middle of the wing.

The scapular vein follows a similar course as the mediastinal, always about as far removed from it as it is from the margin, excepting in the apical third; where its distance from the mediastinal is slightly greater, so as to carry its termination, no doubt, exactly to the tip of the wing; no cross veins can be seen to connect this vein with the mediastinal. No other veins can be traced at the extreme base of the wing between the scapular and the lower margin; but at a short distance (about 2–3 mm.) from the base of the scapular vein, and where its course turns from a descending to a longitudinal direction, a strong transverse vein depends from it, directed a very little obliquely outward, and reaching from one-third to one-half way to the lower margin of the wing; and from near and at the lower extremity of this stout transverse vein, other longitudinal veins arise. The uppermost arises from the middle of the lower half of the vein, at a distance from the scapular much greater than the scapular from the costal margin at this point; at first it tends upward, parallel to

the costal margin, but very soon divides into two main stems. These two stems I take to be: the upper the main scapular branch, of which the transverse vein is the base; the lower the externomedian vein, amalgamated with the former at the base, the two being comparable, as will be shown further on, to the same nervures in the Odonata. The connection of the main scapular branch with the veins preserved in the field beyond cannot be directly traced; but from the position of the latter the following account must be substantially correct. It runs in a nearly straight course to the middle of the apical half of the wing, where from not following the arcuate course of the main scapular vein it has diverged considerably from it; here its straight course suddenly terminates, but it passes to the same point on the apical margin (just below or at the apex), by a gentle arcuation subparallel to but distant from the main scapular vein, with which it appears to be nowhere connected by cross veins. This main scapular branch emits two basal and several apical inferior offshoots; the apical offshoots are thrown off at wide angles, at subequidistant intervals from the arcuate portion of the main branch, the first at its bend being abruptly and widely forked not far from its origin, the others being simple and the interspaces apparently free from cross veins. The basal offshoots are probably thrown off (their origin is destroyed) at a little distance either side of the end of the basal third of the wing; and, unlike the apical offshoots, certainly diverge at a very slight angle, and are each similarly forked; the first from the base is forked near its origin, and its upper fork is again divided narrowly about half way to the margin, the general course of all the nearvules of this basal offshoot being broadly arcuate. The other and outer basal offshoot soon runs parallel to the main scapular branch, and is connected with it by a straight oblique cross vein in the middle of the wing, where it forks; a short distance further on a piece is broken from the middle of the wing, and the part beyond is displaced a little with reference to it, and apparently folded a little so as to obscure the exact course of these forks; which seem to become involved with the fork of the first of the apical offshoots, with which, as well as with each other, they are connected by weak, inequidistant, straight, direct or oblique cross veins.

The externomedian vein can be traced in all its parts, excepting an insignificant portion of the tip of the outer of its branches; the main stem takes an arcuate course, parallel to the basal offshoot of the main scapular branch, and terminates on the lower margin just beyond the middle of the wing; half way from the transverse basal vein to the margin it throws off an inferior branch, which soon becomes parallel to it (and where it becomes so is connected by a cross vein to the vein below) and, by an interpolated vein, which appears as a baseward continuation of this inferior branch, to a bent cross vein in the same interspace, just beyond the middle of the basal half of the wing; this cross vein is bent on the externomedian side of the interspace. The internomedian vein is compound, being broken at the lower extremity of the transverse basal vein (before which it is not seen) into two compound branches, each throwing off a couple of inferior curved offshoots to the margin, which are connected together by two sets of cross veins,—one belonging only to the nervures of the upper branch, and in continuation of the direct cross nervure in the externo-internomedian interspace; the other set covering both branches and broken, each succeeding vein being carried successively further in, the general course of the whole series being across the middle of the internomedian

area, sub-parallel to the outer series; one or two of the nervules in this area are briefly forked next to the border. The anal veins cannot be seen.

The length of the fragment is 40 mm.; the probable length of the wing 42 mm.; its breadth at the middle is 14 mm., reduced at base to 4 mm.

The most important vein in this wing is the scapular, whose branches occupy about half the outer margin; the externomedian is comparatively unimportant, the internomedian occupying a larger area. The more striking features of the wing besides this are: the origination of the principal scapular branch (from which all the scapular nervules arise) and the externomedian vein from a common stem, having its source in a transverse basal nervule; and the meagreness of the transverse neuration, which in no place shows any sign of reticulation. The point first mentioned finds no parallel among insects excepting in the Odonata, where it is almost precisely similar. There, as I attempted to show many years ago in treating of the structure of the wings of recent and of fossil Neuroptera, the transverse vein termed the arculus in modern nomenclature should be considered as made up of two veins meeting each other. for the upper of the two longitudinal nervures which always originate from it belongs to the scapular vein, while the lower belongs to the externomedian. Here, these two veins appear, at least, to be amalgamated at the base, but it is not impossible, and would indeed seem *a priori* more probable, that they run side by side by side to the arculus, and are merely connate in appearance from the preservation of the fossil. However, this may be, it would seem as if we had in this peculiar structure the presence of an arculus as a forerunner at this early day of the specialized type of Odonata; the main scapular branch arising from the arculus is here, as in all normal modern Odonata, the principal vein of the wing,[1] from which most of the subsidiary branches arise; in these two points this fossil wing is distinctively and decidedly Odonate in character; but if one looks further, one fails to find expected features, now, and even in jurassic time, invariably corellated with those mentioned; especially is a nodus to be sought in vain; the marginal vein runs without break to the tip of the wing; for, although it cannot be followed from want of its perfect preservation, all the neighboring veins can, and the number is similar throughout. So too the fine meshwork of Odonate wings is not only absent, but what cross neuration exists is confined to a dozen or so straight veins for the whole wing. If, however, we consider this uppermost offshoot from the arculus as the main branch of the scapular, and simply imagine the arculus-structure removed, so as to bring this main branch directly and plainly dependant from the scapular vein, one cannot fail to see how close the entire structure would be to what we find in the Sialina. In the latter group indeed, there is no such separation of apical and basal offshoots to the main scapular branch as here, but all the scapular nervules take their rise, not from the vein itself, but as here from a principal scapular branch, arising far back on the scapular vein; the general relations of the different areas of the wing are also much the same in both, while the cross venation is very similar. Here as there, the internomedian vein and its branches are of more importance — cover a wider area and bifurcate far more — than either the externomedian vein on the one side, or the anal on the other. We have here, therefore, as I pointed out

[1] It is termed *vena principalis* in the modern nomenclature of students of Odonata. In some Calopterygidae it does not arise in the same way as in other Odonata, but has transferred its origin to the scapular (median) itself.

when first calling attention to this fossil, the distinctive features of two tolerably well separated groups combined in one individual: certain features of the wing are distinctively Sialid in character; others occur nowhere but in the Odonata. Yet these two groups belong, one to the Neuroptera proper, the other to the Pseudoneuroptera, and we find here the earliest proof of their common origin, in a wing whose type is more distinctly synthetic than any other known. It seems also to bring new and unanticipated evidence in support of my view of the homologies of the vein arising from the arculus in Odonata.

It is plainly impossible for us to place this insect in any known family of Neuroptera. It must be considered the first known member of a family, forming the connecting link between the Neuroptera proper and Pseudoneuroptera, and will be evidence, in so far as it goes, of a closer connection between these two groups, than between the latter and Orthoptera. For this family I would propose the name of Homothetidae, and would characterize it as a family of Neuroptera (*sensu latiori*), allied to Sialina, but in which the principal scapular branch, instead of originating as in Sialina directly from the main stem, usually near the middle of the wing, arises in common with or close beside the externomedian vein, from an arculus near the base of the wing, connecting the scapular and internomedian veins; and in which, further, the basal and apical offshoots from this main scapular stem are differentiated, instead of exhibiting a similar and uniform character.

This insect was found in plant bed No. 8, of Professor Hartt's section, the highest in the series as developed at the Lancaster locality.

VI. Dyscritus vetustus. Pl. 1, fig. 4.

Dyscritus vetustus Scudd., Geol. mag., v, 172, 176 (1868).

Mentioned without name, as probably identical with one of the other species, in my letter to Professor Hartt: On the devonian insects of New Brunswick, p. 1; Bailey, Obs. geol. south. New Br., 140; Amer. journ. sc., (2) xxxix, 357; Can. nat. geol., (n. s.) II, 234; Trans. ent soc. Lond., (3) I, 117 — all in 1865.

The insect briefly mentioned hitherto under this name has not before been figured, and is the least important of the devonian wings. It consists of only a small fragment of a wing, which shows a bit of the lower margin with three or four curved veins running toward it, and connected rather uniformly with one another by cross veins forming quadrate cells. It is plainly distinct from all the others, for the equivalent region in no case is similarly broken. In *Lithentomum Harttii* the corresponding region is indeed not preserved, but the cross veins in the neighboring parts, although weak, straight and direct as here, are so very infrequent and irregular that we cannot presume the parts which are wanting below them to be very different.

The veins preserved are four in number. The uppermost has two inferior branches at short distances, of which only the extreme base of the outer is preserved, while the inner is traceable throughout its extent; it parts from the main vein, which in the brief portion preserved runs nearly parallel to the lower margin, at an ordinary angle and passes in a regular arcuate downward course to the margin. The three veins below this take a course sub-parallel to this, and are sub-equidistant; the upper, at the base of the

part preserved, is a little nearer to the vein above, and to its first branch, than to the vein below, and may possibly, not improbably, be a branch of the first vein mentioned, parting from it further toward the base than the fracture of the specimen allows us to see; the two veins below it seem to belong together; the bit of margin preserved, covering only two interspaces, is slightly convex. The cross veins are weak, but tolerably uniform, and either direct or slightly oblique, or occasionally a little irregular; they are nearly equidistant as a general rule, but more frequent in the outer of the two interspaces touching the margin than elsewhere. The length of the fragment is 15 mm.

The fragment then consists of some curved veins striking the lower margin of a wing, one at least of which is one of two or more inferior and, so far as can be seen, simple branches of a principal longitudinal vein, whose course would make it terminate either at the very tip of the wing, or, if it afterwards curved considerably, very near the extremity of the lower margin. This principal vein probably belongs either to the scapular or externomedian, while the lower curved veins appear like branches of the internomedian vein. The wing cannot therefore be referred to the vicinity of either Platephemera or Gerephemera, both on account of the relations to each other of the veins, and of the nature of the reticulation, the latter being certainly polygonal in this region in both these genera; while the irregular course of the veins themselves in Platephemera and their considerable apical divarication in Gerephemera constitute peculiarities not observed in the simple fragment under discussion. So far as the course of the veins is concerned it can be much better, and indeed very well, compared to Dictyoneura and its allies; but in all these insects the interspaces are filled with a minute polygonal reticulation (wherever it is preserved), which is such a characteristic feature that Dyscritus can by no possibility be considered as very closely allied to them.

The neuration is altogether different in Xenoneura, finding nothing at all comparable in this region. The longitudinality of the veins throughout Lithentomum seems to forbid any close comparison with it. But in Homothetus we do find some points in common with Dyscritus; for while the reticulation is much more sparse in the former, there is a certain regularity about it similar to what we have in the latter, while the curving of the internomedian veins and their parallelism certainly resemble in a general way the same features in Dyscritus. And if we presume the fragment of Dyscritus to be broken from near the middle of the wing, we may see a not distant resemblance between the longitudinal vein of Dyscritus and its two visibly connected branches, and the main branch of the scapular vein in Homothetus; while the upper, independent, curved vein of Dyscritus may be taken perhaps for the externomedian vein, and the other two nervules for branches of the internomedian vein. The resemblance is at least sufficient to make us believe we have here a clue to its relationship; while at the same time it differs so much from it that we cannot associate the two even generically; for if they are to be compared in this way at all, the lower stem of the main scapular branch, as seen in Homothetus, must either have become single and simple in Dyscritus, or it must have assumed the longitudinality and mode of bifurcation of the upper stem.

There is nothing, however, in the fragment to show what the connection of the main scapular branch may have been, and consequently nothing to prevent the reference of this wing to the Sialina, where the relations of the veins would be the same. Judging

by comparison of what we have presumed to be similar parts, we may suppose this wing to have been slightly larger than that of *Homothetus fossilis*, and its probable length not far from 50 mm.

Whatever views are held of the special homologies of the veins, its right to generic distinction from Homothetus, to which it is most closely allied, must be conceded on the ground of the greater simplicity of the neuration.

On account of the insignificance of the fragment, however, and the consequent impossibility of any sure clue to its affinities, it would not have been worth while to confer upon this wing a distinctive generic name, even granting its generic dissociation from all others, were it not for the extreme interest attaching to any insect fragment of such high antiquity.

The remains were found in plant bed No. 8, of Professor Hartt, the highest in the Lancaster series.

VII. Lithentomum Harttii. Pl. 1, fig. 3.

Lithentomum Harttii Scudd., Can. nat. geol., (n. s.) III., 206, fig. 4 (1867); — Ib., Geol. mag., IV, 387, pl. 17, fig. 4 (1867); Ib., Daws., Acad. geol., 2d ed., 525, fig. 183 (1868); — Ib., Amer. nat., I, 630, pl. 16, fig. 5 [*Hartii*] (1868); — Ib., Geol. mag. V, 172, 176 (1868); — Pack., Guide ins., 77, 78, pl. 1, fig. 5 (1869).

Mentioned without name, as the third species, in my letter to Professor Hartt: On the devonian insects of New Brunswick, p. 1; Bailey, Obs. geol. south. New Br., 140; Amer. journ. sc., (2) XXXIX, 357; Can. nat. geol., (n. s.) II, 235; Trans. ent. soc. Lond., (3) II, 117 — all in 1865.

The relic to which this name has been given is the central upper portion of a wing in a very fragmentary condition, but with a bit of the upper margin sufficient to enable one to determine pretty positively the homologies of the veins. A fragment of Calamites has unfortunately covered the base and lower part of the wing, but one or two of the veins appear through it at what must be the very base of the wing, and help to determine its nature. The fragment preserved is 36 mm. long, and 15.5 mm. broad; but the wing was probably 55 mm. long, and perhaps 20 mm. broad, if one may judge from its general appearance only; it certainly represents a large insect.

The marginal vein forms the border. The mediastinal vein in the basal half of the wing, and probably for some distance beyond, runs parallel to and at considerable distance from the border, with which it is connected by very weak oblique cross veins at irregular intervals, which toward the base are considerably more oblique than further outward; this weak construction of the costal margin renders it probable that the wing was a hind one. The scapular vein in the basal quarter of the wing runs in very close proximity to the mediastinal, then parts from it a little, and continues sub-parallel to it, but a little nearer to it than the latter to the border; there appear to be no cross nervules between these veins, but a slight and irregular tortuous longitudinal line like a mere puckering of the membrane; at some distance before the middle of the wing this vein puts forth at a slight angle an inferior branch, which takes an arcuate course sub-parallel to the vein, and is forked about as far beyond the middle of the wing, apparently, as it arose anterior to it, both offshoots taking a longitudinal direction.

The externomedian vein next the base of the wing is somewhat distant from the scapular, is afterwards still further removed from it, and, in the middle half or more of the wing, has a somewhat irregular, sinuous, longitudinal course, sub-parallel to the scapular vein; just before the end of the basal quarter it appears to have a straight oblique inferior branch widely divergent from it; this is the vein next the lower margin of the fragment; by its course it would appear to be a branch of the externomedian, but it is not impossible that it may be the internomedian vein; whichever it is, it forks in the middle of the second quarter of the wing, each fork being straight, simple and slightly divergent. From the point where this inferior branch appears to be thrown off from the externomedian vein, a superior branch appears also to be emitted; it scarcely parts from the vein and runs only a short distance along the interspace in a nearly straight line and then dies out. Beyond this the externomedian vein throws off two, so far as can be seen simple, branches, which are nearly straight, obliquely longitudinal, and part from the vein, one at the middle of the wing, the other a short distance before it or just below the branch of the scapular vein. The interspaces thus formed below the scapular vein are very unequal and variable in breadth, giving the neuration a feeble uncertain appearance, which is heightened by the irregular distribution of the cross veins, which, although nearly always straight and transverse, sometimes bridge the narrowest, sometimes the broadest parts of the interspaces; they are exceedingly feeble and infrequent, the largest number being found in the interspace between the scapular and externomedian veins, although they may have been present in some of the areas where they cannot now be seen.

We shall seek in vain to accommodate this wing in any of the modern families of Neuroptera. There are none excepting the Ephemeridae, the Embidae and perhaps the Raphidiidae, in which the externomedian vein has such a preponderating importance, and in none of these do the scapular or externomedian veins have a structure at all similar. The structure of the scapular vein is somewhat similar to what we find in the Sialina, but is widely different from it in the paucity of the offshoots of the scapular branch, in which this wing is comparable to Xenoneura only. The structure of the externomedian vein is also distantly similar to that of the Sialina, but in this family, in modern times at least, the number of principal branches is always fewer, they never assume such a longitudinal course, and never cover so great an area. We must, therefore, separate this group from all known families, as one having its nearest affinities to Sialina in modern times, and perchance to Xenoneuridae in the ancient; and, considering it as in some sense a precursor of the Sialina, may call it Cronicosialina.[1] It should be looked upon as a family of Neuroptera proper, of feeble neuration, in which the scapular vein emits a main branch near the middle of the wing, which, running nearly parallel to the main vein, emits one or at most two subsidiary, also longitudinal, simple offshoots. The externomedian vein, tolerably distant from the former throughout, terminates near the tip of the wing, emitting two or three branches at very unequal distances apart, all of them longitudinal and all but the basal simple; the irregular interspaces thus formed are crossed at very unequal distances by very feeble but straight cross veins. The lower veins are unknown.

This specimen is the most obscure of all the devonian insects and would have been overlooked by any less keen-sighted observer than the late Professor C. F. Hartt.

[1] *Κρονικός*, old fashioned.

Very few persons seeing it would recognize it as an insect, yet it was the first insect found by him which he recognized as such. It is on this account that I have selected this of all the devonian wings to commemorate his discovery. It comes from plant-bed No. 8, the highest in the series.

VIII Xenoneura antiquorum. Pl. 1, figs. 5, 6, 7.

Xenoneura antiquorum Scudd., Can. nat. geol., (n. s.) III, 206, fig. 5 (1867); — Ib., Geol. mag., IV, 387–88, pl. 17, fig. 5 (1867); — Ib., Dawson, Acad. geol., 2d ed., 525–26, fig. 184 (1868); — Ib., Amer. nat., II, 163, fig. 1 (1868); — Ib., Geol. mag., V, 174, 176 (1868).

Mentioned without name, as the fifth species, in my letter to Professor Hartt: On the devonian insects of New Brunswick, p. 1; Bailey, Obs. geol. south. New Br., 140; Amer. journ. sc., (2) XXXIX, 357; Can. nat. geol., (n. s.) II, 235; Trans. ent. soc. Lond., (3) II, 117,—all in 1865; see also Amer. journ. sc., (2) XL, 271.

This fossil is represented by a fractured basal fragment of a wing, probably including a little more than half of it. It is the smallest of the devonian insects, the wing having probably measured only a little more than 18 mm. in length. It was long and slender, broadest near the middle, and probably tapered to a rounded but somewhat produced extremity, as in certain species of Dictyoneura. The costal border in the preserved portion (probably a little more than half of the whole) is gently convex; probably beyond the middle it is straight nearly to the tip, as represented on the plate; the portions of the lower margin preserved indicate that this was more strongly arcuate but not full next the base; the direction of the margins and the course of the distant veins indicate, as stated, a tapering tip, which was probably rounded, and in no way angular.

The marginal vein forms the border. The mediastinal vein is simple and gently arcuate; at first it curves gently in the opposite sense to the margin, from which it is somewhat distant, and with which it is connected by faint, nearly transverse, or, away from the base, gently oblique cross veins, not very closely approximated. At the beginning of the second quarter of the wing, it is about as distant from the scapular vein as from the margin, and thereafter runs nearly parallel with the latter, but with a slightly stronger curve, to a little past the middle of the wing; where it suddenly terminates in a cross vein bent at a right angle, the upper half a little the longer, by which it is connected with the veins on either side of it; a somewhat similar termination of this vein is shown in Goldenberg's figure of *Dictyoneura libelluloides*.

The scapular vein is one of the most important in the wing. In the part of the wing preserved it is very straight. Next to the base it is in exceedingly close proximity to the mediastinal, diverging gently from it by the curve of the latter at about the end of the basal fifth of the fragment, until it is as distant from the mediastinal as the mediastinal is from the margin, and again gradually approaches it; it is about equidistant from the border at the end of the fragment, and where the mediastinal diverges from it; beyond the tip of the mediastinal, it probably continues its straight course at first, or even trends slightly upward to take the place of the mediastinal vein, until it is in close proximity to the border, and then follows nearly the curve of the latter, gradually approaching it until

near the tip; but the track of the vein beyond the tip of the mediastinal is of course conjectural.

At a little beyond the end of the first third of the wing, it emits at a considerable angle an inferior branch, which, at about half way from its base to the tip of the mediastinal, or at just about the middle of the wing, begins to curve, so as to assume a direction parallel to the main vein, and at the same time forks; this whole branch is very faint, and is almost effaced at the fork next which the wing is fractured. To judge from the course of the other veins, one and only one of the offshoots of that branch is again simply forked; which, it would be impossible to say; but the upper offshoot (with its upper fork, if it divides) most probably runs sub-parallel to, and at considerable distance from, the main scapular vein, very gradually approaching it, especially apically where it curves downward, until it terminates, probably at the very apex of the wing. The sketch in fig. 5, however, represents the lower branch as forked, at a little past its middle; there can be little doubt that the branches impinge upon the margin at about the distance apart that is indicated, or at a little less distance apart than the branches are seen to abut on the fragment of the lower margin which is preserved. The only question is concerning the basal attachment of the vein which strikes the border the second below the scapular vein itself; if not attached as represented in the plate, it originates from the branch of the scapular vein at probably a little less than half the distance between its first forking and the apex.

The vein lying next below this, and which appears on the plate (fig. 5) to have a double attachment to the scapular vein, seems to be the externomedian vein. That its basal half, like that of the preserved portion of the scapular branch, is very faintly indicated on the stone seems due to some accident of preservation, for its apical branching part is distinct. It appears to originate from the scapular vein a a little more than half way from the base of the wing to the origin of the scapular branch; its basal portion must therefore be either connate with the scapular vein, or be so closely connected with it by the accidents of preservation as to be inseparable from it. It diverges from the scapular at the same angle as the scapular branch, is very soon connected with the adjacent vein below by a short cross nervule of unusual distinctness, bends outward a little beyond this cross nervule, and at an equal distance beyond is again bent to its former course; here it is connected to the scapular vein by a faint oblique cross vein, which is almost exactly continuous with the subsequent part of the externomedian, and reaches the scapular vein directly above the distinct cross vein above mentioned; thus giving the mediastinal vein the appearance of having a double base, and enclosing between its basal attachments an elongated subrhomboidal cell. Beyond these basal divisions the vein runs in a straight oblique course to just before the centre of the wing, where it forks widely, the upper branch being simple and excepting for a gentle arcuation at its base nearly straight and a little more longitudinal than the main stem; the lower branch nearly continues the direction of the main stem, and at a little less than half way to the margin forks, again widely, but symmetrically, the offshoot being simple, the upper again forked half way to the margin, the final upper fork being nearly horizontal and striking the border in the middle of the apical half of the wing.

The internomedian vein seems to be represented by two widely separated simple veins, the course of which, so far as they can be traced, would seem to indicate that they have a common origin very near or at the base of the wing, directly below the common stem of the scapular and externomedian veins. The upper branch first comes into view directly beneath this stem, running parallel to it, and not very far away from it, but at double the distance from it that the mediastinal vein is at this point, which is before the end of the basal quarter of the wing; when the mediastinal vein curves upward from the scapular, this curves downward in about the same degree, until it reaches the distinct short cross vein which unites it, as before stated, to the externomedian vein; here it bends downward, becomes more distinct than any of the nervules between it and the main scapular vein (previously it had been rather inconspicuous), and runs in a nearly direct faintly arcuate course to the middle of the lower margin of the wing, gently diverging throughout from the externomedian vein and its nearer branches. The lower branch is first seen in the very centre of the basal third of the wing, from which point it passes in a nearly straight course almost parallel to the distincter portion of the other branch, and is as heavily marked. The anal vein is perhaps simple, running at first downward and curving outward, subparallel to but distant from the lower basal margin, becoming just before the middle of its regular course straight and distinct, when it diverges slightly from the border of the wing, and inclines distinctly although not greatly toward the lower internomedian branch, continuing in this course until it reaches a distinct oblique cross vein which unites it to the latter in the middle of the basal half of the wing; here it bends abruptly downward at right angles to the cross vein, and runs doubtless into the margin; the cross vein is nearly transverse to the interspace in which it lies, and is about parallel to, and is of the same length as, the upper limb of the bent cross vein in which the mediastinal vein terminates. Next the basal margin of the wing is a brief simple shoot directed almost vertically downward, which may be an inferior basal branch of the anal vein. The other lines between the internomedian veins and the margin, seen in fig. 5, represent merely fractures in the stone.

Besides the three distinct cross veins mentioned,—(1) that in which the mediastinal vein terminates, (2) that between the upper internomedian branch and the externomedian vein; and (3) that connecting the lower internomedian branch and the anal vein — and the weak cross veins visible in the interspace above the mediastinal vein (of which only those in the basal half are represented in fig. 5), there are in various parts of the wing exceedingly indistinct, very weak, very closely approximated, but unequally distant cross veins, transverse or nearly transverse to the interspaces, sometimes curved but never showing any tendency to unite so as to form any kind of reticulation; it is probable that they exist throughout the wing, or at least below the main scapular vein; they are most distinct in the externomedian interspaces, and in those on either side of the internomedian branches, especially next the nervules themselves, as may be seen in fig. 5 on either side of the lower internomedian branch, where they are more distinct than in any other part of the wing; this mode of fracturing the interspaces, rather than reticulation, is the more marked from the exceedingly open and distant neuration.

Besides these normal features of neuration there are some other characteristics in this wing, purposely left for description to the end. These are some peculiar marks near the base of the wing, originally described by me as "apparently independent veinlets, forming portions of concentric rings." These ridged rings overlie the probable position, as here described, of the basal part of the lower internomedian branch, and lie just beneath the initial divergence of the mediastinal and scapular veins; they consist of an alternate series of broken concentric grooves and furrows, some faint, others in places very distinct, extending over nearly half the width of the wing at this point, *i. e.*, almost reaching the upper branch of the internomedian vein on the one hand and the anal vein on the other; the most distinct are three short, shallow furrows, with very rounded low ridges between them upon the upper side, next the upper branch of the internomedian vein; the outer of these is distant from the extreme mark upon the opposite side about 2.2 mm.; the central region, rather less than a millimeter in diameter, presents a slightly elevated, irregular, granulated surface, like many of the rougher parts of the stone outside the wing, and has no peculiar structure; the whole lies directly upon what would be the continuation of the lower branch of the internomedian vein were it present, and apparently obliterates it; one of the outermost grooves, an extremely faint and delicate one, crosses the anal vein at a very sharp angle. This peculiar feature in the wing I formerly compared to the stridulating apparatus of the Locustariae, and suggested that this insect thereby united characteristics now found only separated, some in Neuroptera and some in Orthoptera. Several naturalists, *e. g.*, Darwin, Dawson, and Packard, following my suggestion, have used this as a striking illustration of synthetic character in early types of animals, and have pictured this as the earliest example of stridulation. I am now obliged to confess that I have led them altogether astray; this peculiarity, although bearing a strong superficial resemblance to the stridulating organs in Locustariae, having, I believe, nothing whatever to do with the wing itself. The stridulating apparatus of Orthoptera, whenever it concerns the wings, is invariably based on a modification of existing veins; in its simplest forms it is the mere thickening of certain nervules, and furnishing them with a sharp or rough edge. In the original appearance of a stridulating organ in insects, we should look for some such simple form as the initial stage. But in this fossil wing we find nothing of the sort; no one of the concentric lines or grooves are continuous with any of the neighboring veins. The only appearances which favor such a view are: (1) the openness of the neuration at this point, which allows this great scar to lie at the base of the wing without disturbing more than one of the veins; (2) the curve of the anal vein, which has the appearance of passing around this obstruction; but the course of which is in keeping with the curve of the lower margin of the wing, equally explaining it; and (3) the curve of the cross veins in the neighborhood of the scar, as seen on either side of the lower internomedian branch in fig. 5; which veins, however, when narrowly examined, are seen to form angles with the more prominent concentric grooves and ridges. These ridges, too, are not of a form suitable for the production of sound, the depressions or elevations being extremely smooth and gradual; they are also of very unequal size and thickness; they do not occur in the anal area, as in all Locustariae, but in the internomedian;

and they have just sufficient regularity to render it most probable that the central, irregular, rough, and slightly elevated mass is either the relic of a foreign substance, which has fallen upon the wing, subsequent pressure upon which, when the membrane of the wing formed, so to speak, a part of the floor upon which it lay, has caused the mud and membrane together to assume the present appearance; or, that we chance here to have stumbled on a wing which, in the nymph condition, has met with some accident, producing in the imago a blister-like distortion, such as those figured by Mocquerys, as suggested to me by Dr. Hagen, in the elytra of *Carabus monilis*, *Mesonphalia gibba*, *Timarcha rugosa*, and as must have been observed in the veined wings of insects of the other orders by all entomologists This last supposition would better account for the greater prominences of the peculiar markings around one part of the scar than elsewhere, and for the apparent partial conformity of the cross venation to the contour of the scar. Whichever way it be considered, it does not now appear to me reasonable to maintain my former hypothesis of a stridulating organ, to which nevertheless there is, as stated, a remarkable general resemblance. That such a stridulating organ would be a great anomaly no one can question, and the proposition should not be maintained in the face of the objections which careful and prolonged study and comparison elicit.

But putting aside its extraneous features, we may discuss the affinities of this insect on the basis of the unquestionable characteristics of its neuration, and shall find in these enough to excite our interest and even to perplex us. In its general features the wing is plainly neuropterous. It would appear from the strength of the margin to be an upper wing, and in its form to resemble that of many true Neuroptera; its sweeping forking branches with direct transverse cross venation attest the same proposition, but when we come to compare it with known types, we shall find it extremely difficult to place it. Its very open neuration is one general feature which is peculiar; the presence of two or three very prominent cross veins, with an extreme multitude of feeble cross veins never breaking up into an irregular reticulation, is certainly strange; so is the termination of the mediastinal vein, and still more the entire simplicity and extreme separation of the internomedian veins, occupying so large an area of the wing without a fork, and connected in so unusual a manner with the veins on either side; the apparent absolute amalgamation of the bases of the scapular and externomedian veins in such early insects is very unexpected;—and all combine to form an ensemble which is the odder for the general simplicity of the neuration. It would be hard to say which is the most prominent vein in the wing; the scapular, externomedian and internomedian occupy about equal areas, and while the two former branch more than the latter, their nervules are comparatively much feebler.

In the openness and sparseness of the neuration and in the paucity (but not at all in the position) of the principal cross veins, it bears a certain resemblance to the Coniopterygidae and to no other neuropterous family; but the differences are far greater and more important than the resemblances and scarcely need be stated.

There are also some features which give it a sialidan appearance; if we suppose, as we may, that the second nervule reaching the margin below the main scapular vein arises from the main scapular branch, we shall have a condition of the scapular vein very like that of the Sialina, excepting in the slight number of offshoots from its branch, which would be very abnormal; in the near or actual amalgamation of the externomedian

with the scapular vein, there is also nothing to separate it from the Sialina, excepting their amalgamation for so great a distance; but the structure of all the other veins and the peculiarities of the cross venation is very different from the same points in the Sialina.

In the course of most of the main veins and their mode of branching, it has some resemblance to the Raphidiidae, but it has no affinity whatever with that group in the peculiar directions of the nervules and their connection by distant cross veins, so as to form large polygonal cells, which is one of the most striking of the characteristic features of Raphidiidae.

The apical two-thirds of the wing (excluding, therefore, the attachments of most of the veins) are in sufficient harmony with these parts in the carboniferous Dictyoneurae to presume, at first, that the wing will fall in the ancient order of Palaeodictyoptera. As yet, however, we know too little of the extent and even of the peculiar characteristics of this group to say whether or not the structure of the base of the wing will allow its location here; certainly it will not admit its being placed in the same family with the genus Dictyoneura; and at present this is, perhaps, all that we can say until the structure of all the ancient wings shall have been most carefully studied.

It is in large measure in those points of structure which Dictyoneura shares with the Ephemeridae, that Xenoneura is comparable to former, and we therefore see in this wing ephemeridan, sialidan, raphidian and coniopterygidan features, combined with others peculiar to itself. Whatever the closest affinities of the wing may prove to be, it must certainly, by its combination of characters, bridge over the gulf now separating the wing features of Neuroptera and Pseudoneuroptera; and these various considerations assure us of its family distinction from any known ancient or modern type of Neuroptera, and of the propriety of applying to the group it represents the family name of Xenoneuridae.

This species, with *Gerephemera simplex*, came from the lowest insect-producing beds of the Lancaster Shales, called plant bed No. 2, by Professor Hartt.

IX. General Summary.

It only remains to sum up the results of this re-examination of the devonian insects, and especially to discuss their relation to later or now existing types. This may best be done by a separate consideration of the following points:

1. There is nothing in the structure of these earliest known insects to interfere with a former conclusion [1] that the *general type of wing structure has remained unaltered from the earliest times*. Three of these six insects (Gerephemera, Homothetus and Xenoneura) have been shown to possess a very peculiar neuration, dissimilar from both carboniferous and modern types. As will also be shown under the tenth head, the dissimilarity of structure of all the devonian insects is much greater than would be anticipated; yet all the features of neuration can be brought into perfect harmony with the system laid down by Heer.

2. *These earliest insects were hexapods*, and as far as the record goes preceded in time both arachnids and myriapods. This is shown only by the wings, which in all known insects belong only to hexapods, and in the nature of things prove the earlier apparition of that group. This, however, is so improbable on any hypothesis, that we must conclude the record to be defective.

[1] The early types of insects. Mem. Bost. Soc. Nat. Hist., III, 21.

3. *They were all lower Heterometabola.* As wings are the only parts preserved, we cannot tell from the remains themselves whether they belong to sucking or to biting insects; for, as was shown in the essay already referred to, this point must be considered undetermined concerning many of the oldest insects until more complete remains are discovered.

They are all allied or belong to the Neuroptera, using the word in its widest sense. At least two of the genera (Platephemera and Gerephemera) must be considered as having a closer relationship to Pseudoneuroptera than to Neuroptera proper, and as having indeed no special affinity to the true Neuroptera other than is found in Palaeodictyoptera. Two others (Lithentomum and Xenoneura), on the contrary, are plainly more nearly related to the true Neuroptera than to the Pseudoneuroptera, and also show no special affinity to true Neuroptera other than is found in Palaeodictyoptera. A fifth (Homothetus), which has comparatively little in common with the Palaeodictyoptera, is perhaps more nearly related to the true Neuroptera than to the Pseudoneuroptera, although its pseudoneuropterous characters are of a striking nature. Of the sixth (Dyscritus) the remains are far too imperfect to judge clearly, but the choice lies rather with the Pseudoneuroptera or with Homothetus. The devonian insects are then about equally divided in structural features between Neuroptera proper and Pseudoneuroptera, and none exhibit any special orthopterous, hemipterous or coleopterous characteristics.

4. *Nearly all are synthetic types of a comparatively narrow range.* This has been stated in substance in the preceding paragraph, but may receive additional illustration here. Thus Platephemera may be looked upon as an ephemerid with an odonate reticulation; Homothetus might be designated as a sialid with an odonate structure of the main branch of the scapular vein; and under each of the species will be found detailed accounts of any combination of characters which it possesses.

5. *Nearly all bear marks of affinity to the carboniferous Palaeodictyoptera,* either in the reticulated surface of the wing, its longitudinal neuration, or both. But besides this there are some, such as Gerephemera and Xenoneura, in which the resemblance is marked. Most of the species, however, even including the two mentioned, show palaeodictyopteran characters only on what might be called the neuropterous side; and their divergence from the carboniferous Palaeodictyoptera is so great that they can scarcely be placed directly with the mass of palaeozoic insects, where we find a very common type of wing structure, into which the neuration of devonian insects only partially fits. For:

6. *On the other hand, they are often of more and not less complicated structure than most Palaeodictyoptera.* This is true of the three genera mentioned above with peculiar neuration, but not necessarily of the others, and it especially true when they are compared with the genus Dictyoneura and its immediate allies. There are other Palaeodictyoptera in the carboniferous period with more complicated neuration than Dictyoneura, but these three devonian insects apparently surpass them, as well as very nearly all other carboniferous insects. Furthermore:

7. With the exception of the general statement under the fifth head, *they bear little special relation to carboniferous forms, having a distinct facies of their own.* This is very striking; it would certainly not be possible to collect six wings in one locality in the carboniferous rocks, which would not prove, by their affinity with those already

known, the carboniferous age of the deposit. Yet we find in this devonian locality not a single one of the Palaeoblattariae or anything resembling them; and more than half the known insects of the carboniferous period belong to that type. The next most prevailing carboniferous type is Dictyoneura and its near allies, with their reticulated wings. Gerephemera only, of all the devonian insects, shows any real and close affinity with them; and even here the details of the wing structure, as shown above, are very different. The apical half of the wing of Xenoneura (as I have *supposed* it to be formed) also bears a striking resemblance to the dictyoneuran wing; but the base, which is preserved, and where the more important features lie, is totally different. The only other wing which shows particular resemblance to any carboniferous form (we must omit Dyscritus from this consideration, as being too imperfect to be of any value) is Platephemera, where we find a certain general resemblance to *Ephemerites Rückerti* Gein., and *Acridites priscus* Andr., but this is simply in the form of the wing and the general course of the nervules; when we examine the details of the neuration more closely we find it altogether different, and the reticulation of the wing polygonal and not quadrate as in the carboniferous types.[1] In this respect indeed, Platephemera differs not only from all modern Ephemeridae, but also from those of other geological periods.[2] Another prevailing carboniferous type, the Termitina, is altogether absent from the devonian. Half a dozen wings, therefore, from rocks known to be either devonian or carboniferous, would probably establish their age.

8. *The devonian insects were of great size, had membranous wings, and were probably aquatic in early life.* The last statement is simply inferred from the fact that all the modern types most nearly allied to them are now aquatic. As to the first, some statements have already been made; their expanse of wing probably varied from 40 to 175 mm. and averaged 107 mm. Xenoneura was much smaller than any of the others, its expanse not exceeding four centimetres, while the probable expanse of all the rest was generally more than a decimeter, only Homothetus falling below this figure. Indeed if Xenoneura be omitted, the average expanse of wing was 121 mm., an expanse which might well be compared to that of the Aeschnidae, the largest, as a group, of living Odonata. There is no trace of coriaceous structure in any of the wings, nor in any are there thickened and approximate nervules — one stage of the approach to a coriaceous texture.

9. *Some of the devonian insects are plainly precursors of existing forms, while others seem to have left no trace.* The best examples of the former are Platephemera, an aberrant form of an existing family; and Homothetus, which, while totally different in the combination of its characters from anything known among living or fossil insects, is the only palaeozoic insect possessing that peculiar arrangement of veins found at the base of the wings in Odonata, typified by the arculus, a structure previously known only as early as

[1] Dr. H. B. Geinitz has kindly re-examined *Ephemerites Rückerti* at my request, and states that the reticulation is in general tetragonal, but that at the extreme outer margin the cells appear in a few places to be elliptical five- or six-sided.

[2] The Dictyoneurae and their allies, as may be inferred, are considered as belonging to the Palaeodictyoptera, although their ephemeridan affinities are not disregarded.

the jurassic. Examples of the latter are Gerephemera, which has a multiplicity of simple parallel veins, next the costal margin of the wing, such as no other insect, ancient or modern, is known to possess; and Xenoneura, where the relationship of the internomedian branches to each other and to the rest of the wing is altogether abnormal. If too, the concentric ridges, formerly interpreted by me as possibly representing a stridulating organ, should eventually be proved an actual part of the wing, we should have here a structure which has never since been repeated even in any modified form.

10. *They show a remarkable variety of structure, indicating an abundance of insect life at that epoch.* This is the more noticeable from their belonging to a single type of forms, as stated under the seventh head, where we have seen that their neuration does not accord with the commoner type of wing structure found in palaeozoic insects.[1] These six wings exhibit a diversity of neuration quite as great as is found among the hundred or more species of the carboniferous epoch; in some, such as Platephemera, the structure is very simple; in others, like Homothetus and Xenoneura, it is somewhat complicated; some of the wings, as Platephemera and Gerephemera, are reticulated; the others possess only transverse cross veins more or less distinct and direct. No two wings can be referred to the same family, unless Dyscritus belongs with Homothetus — a point which cannot be determined from the great imperfection of the former. This compels us to admit the strong probability of an abundant insect fauna at that epoch; although many palaeozoic localities can boast a greater diversity of insect types, if we look upon their general structure as developed in after ages, not one in the world has produced wings exhibiting in themselves a wider diversity of neuration; for the neuration of the Palaeodictyoptera is not more essentially distinct from that of the Palaeoblattariae or of the ancient Termitina, than that of Platephemera or Gerephemera on the one hand is from that of Homothetus or of Xenoneura on the other. Unconsciously, perhaps, we allow our knowledge of existing types and their past history to modify our appreciation of distinctions between ancient forms. For while we can plainly see in the Palaeoblattariae the progenitors of living insects of one order, and in other ancient types the ancestors of living representatives of another order; were we unfamiliar with the divergence of these orders in modern times, we should not think of separating ordinally their ancestors of the carboniferous epoch. It may easily be seen, then, how it is possible to find in these devonian insects — all Neuroptera or neuropterous Palaeodictyoptera — a diversity of wing structure greater than is found in the carboniferous representatives of the modern Neuroptera, Orthoptera and Hemiptera.

11. *The devonian insects also differ remarkably from all other known types, ancient or modern; and some of them appear to be even more complicated than their nearest living allies.* With the exception of Platephemera, not one of them can be referred to any family of insects previously known, living or fossil; and even Platephemera, as shown above, differs strikingly from all other members of the family in which it is placed, both in general neuration and in reticulation; to a greater degree even than the most aberrant genera of that family do from the normal type. This same genus is also more complicated in wing structure than its modern allies; the reticulation of the wing in certain

[1] Cf. Mem. Bost. Soc. Nat. Hist., III, 19, note 1.

structurally defined areas is polygonal and tolerably regular, instead of being simply quadrate; while the intercalated veins are all connected at their base, instead of being free. Xenoneura also, as compared with modern Sialina, shows what should perhaps be deemed a higher (or at least a later) type of structure, in the amalgamation of the externomedian and scapular veins for a long distance from the base, and in the peculiar structure and lateral attachments of the internomedian veins; in the minuter and feebler cross venation, however, it has an opposite character.

12. *We appear, therefore, to be no nearer the beginning of things in the devonian epoch, than in the carboniferous*, so far as either greater unity or simplicity of structure is concerned; and these earlier forms cannot be used to any better advantage than the carboniferous types in support of any special theory of the origin of insects. All such theories have required some Zoaea, Leptus, Campodea, or other simple wingless form as the foundation point; and this ancestral form, according to Haeckel at least, must be looked for above the silurian rocks. Yet we have in the devonian no traces whatever of such forms, but on the contrary, as far down as the middle of this period, winged insects with rather highly differentiated structure, which, taken together, can be considered lower than the mass of the upper carboniferous insects, only by the absence of the very few Hemiptera and Coleoptera which the latter can boast. Remove those few insects from consideration (or simply leave out of mind their future development to very distinct types), and the middle devonian insects would not suffer in the comparison with those of the upper carboniferous, either in complication or in diversity of structure. Furthermore, they show no sort of approach toward either of the lower wingless forms, hypothetically looked upon as the ancestors of tracheate Articulata.

13. *Finally, while there are some forms which, to some degree, bear out expectations based on the general derivative hypothesis of structural development, there are quite as many which are altogether unexpected, and cannot be explained by that theory, without involving suppositions for which no facts can at present be adduced.* Palephemera and Gerephemera are unquestionably insects of a very low organization related to the existing may-flies, which are well known to be of inferior structure, as compared with other living insects; these may-flies are indeed among the most degraded of the sub-order to which they belong, itself one of the very lowest sub-orders. Dyscritus too may be of similar degradation, although its resemblance to Homothetus leaves it altogether uncertain. But no one of these exhibits any inferiority of structure when compared with its nearest allies in the later carboniferous rocks, and they are all higher than some which might be named. While of the remaining species it can be confidently asserted that they are higher in structure than most of the carboniferous types, and exhibit syntheses of character differing from theirs. It is quite as if we were on two distinct lines of descent when we study the devonian and the carboniferous insects; they have little in common, and each its peculiar comprehensive types. Judging from this point of view, it would be impossible to say that the devonian insects showed either a broader synthesis or a ruder type than the carboniferous. This of course may be, and in all probability is, because our knowledge of carboniferous insects is, in comparison, so much more extensive; but, judging simply by the facts at hand, it appears that the carboniferous insects carry us back both to the

more simple and to the more generalized forms. We have nothing in the devonian so simple as Euephemerites, nothing so comprehensive as Eugereon, nothing at once so simple and comprehensive as Dictyoneura. On the derivative hypothesis, we must presume, from our present knowledge of devonian insects, that the Palaeodictyoptera of the carboniferous are already, in that epoch, an old and persistent embryonic type (as the living Ephemeridae may be considered to-day, on a narrower but more lengthened scale); that some other insects of carboniferous times, together with most of those of the devonian, descended from a common stock in the lower devonian or silurian period; and that the union of these with the Palaeodictyoptera was even further removed from us in time; — carrying back the origin of winged insects to a far remoter antiquity than has ever been ascribed to them; and necessitating a faith in the derivative hypothesis, which a study of the records preserved in the rocks could never alone afford; for no evidence can be adduced in its favor based only on such investigations. The profound voids in our knowledge of the earliest history of insects, to which allusion was made at the close of my paper on the Early types of insects, are thus shown to be even greater and more obscure than had been presumed. But I should hesitate to close this summary without expressing the conviction that some such earlier unknown comprehensive types as are indicated above did exist and should be sought.

X. Note on the Geological Relations of the Fossil Insects from the Devonian of New Brunswick. By Principal Dawson, LL.D., F.R.S., &c.

The beds affording these remains occur in the vicinity of the city of St. John, New Brunswick, and are well exposed on the shores of Courtney Bay, on the east side of the city, and at Duck Cove, Lancaster, on its western side. They consist of sandstones, shales, and conglomerates, having an aggregate thickness of about 7,500 feet,[1] as shown in the following generalized section, in ascending order:—

1. *Bloomsbury Conglomerate* — Reddish-gray conglomerate with interstratified hard red shale. 500 feet.
2. *Dadoxylon Sandstone* — (Lower part of Little River Group in my Acadian Geology). Gray sandstone and grit, with beds of gray and black graphitic shale — Fossil plants, etc. 2,800 feet.
3. *Cordaite Shales* — (Upper part of the Little River Group) — red, gray and black shales, with beds of sandstone and conglomerate — Fossil Plants, etc. 2,400 feet.
4. *Mispec Conglomerate* — Red conglomerate and shale. 1,800 feet.

In the vicinity of St. John, these beds rest on cambrian rocks of the Acadian (Menevian) group, and are overlain unconformably by lower carboniferous ("sub-carboniferous") conglomerates, which in their extension eastward are associated with the Albert shales holding fossil fishes and plants of characteristic lower carboniferous types.[2] Elsewhere in

[1] Report of Bailey and Mathew, Geol. Survey of Canada, 1871. In the author's Acadian Geology, the thickness is given as 9500 feet; but later observations have reduced the thickness of the lower members.

[2] See for details the author's Acadian Geology, 3d Edition.

Southern New Brunswick, they overlie laurentian and huronian rocks, and are seen to rise unconformably from beneath the carboniferous rocks of the great central coal-formation area of New Brunswick.[1] They are everywhere more disturbed and altered than the overlying carboniferous beds; and Messrs. Bailey and Matthew have shown that certain intrusive masses and dykes of granite, known to be of pre-carboniferous age, were erupted subsequently to the deposition of these beds.

The vegetable fossils of this formation are very numerous. I have catalogued or described from it upwards of 50 species, belonging to the genera Dadoxylon, Sigillaria, Calamites, Asterophyllites, Lepidodendron, Cordaites, Psilophyton, Neuropteris, Sphenopteris, Hymenophyllites, Pecopteris, &c.; the whole constituting a well-marked devonian assemblage, distinguishable from the upper devonian flora of Perry in Maine, which is perhaps newer than the Mispec conglomerate, and still more distinct from the lower carboniferous flora of New Brunswick and Nova Scotia, while on the other hand it is incomparably better developed than any known flora of silurian age. Owing to the richness of this flora, and to the fact that some genera and species of plants appear earlier in North America than in Europe, some European palaeobotanists have been unwilling to admit the devonian age of this formation, but entirely without good reason.

That some of the species of the St. John beds, as *Calamites transitionis* (=*C. radiatus* of Brongniart), are found in the lower carboniferous of Europe, is not wonderful, as in the devonian as well as in subsequent periods the flora of America has been somewhat in advance of that of Europe. Still the prevalent plants in the St. John beds are distinctively erian or devonian and not carboniferous. Further, recent discoveries of tree-ferns and petioles of ferns in great abundance in the devonian of New York, and as low as the Hamilton group, have shown that the devonian must have been even more remarkable than the carboniferous for the abundance and variety of its ferns. A few additional species of ferns found among specimens remaining in Professor Hartt's collections will shortly be described.

The crustaceans recognized in these beds are *Eurypterus pulicaris* Salter; *Amphipeltis paradoxus* Salter, a precursor of the Stomapods; and a pygidium of a small trilobite, unfortunately too imperfect for determination. A species of *Spirorbis*, which I have described as *S. erianus*,[2] occurs attached to leaves of Cordaites, and is distinct from the common *Spirorbis* of the coal-measures (*S. carbonarius* or *pusillus*). A fragment of a spiral shell may possibly represent a devonian pulmonate, and will be noticed in a forthcoming paper on the pulmonates of the carboniferous. No other animal remains have been found in these beds, except the fossil insects. The conditions of deposit were probably estuarine rather than marine, and the abundant fossil plants testify to the proximity of land.

It is difficult to correlate the subdivisions of the devonian in eastern Canada, with those in the great erian area of New York and western Canada, owing to the absence of the marine limestones, so characteristic of the latter. In my report on the fossil plants of the devonian and upper silurian of Canada,[3] I have, however, stated some grounds

[1] Bailey and Matthew's Reports, which see also for details of the structure and relations of the devonian and associated formations, in southern New Brunswick.

[2] Report on devonian plants. Geol. Surv. Canada, 1871.

[3] Geol. Survey of Canada, 1871.

for believing that the Dadoxylon sandstone and Cordaite shales may be equivalents of the Hamilton group in New York and Ohio, which has afforded some fossil plants comparable with those of the St. John beds, especially trunks of conifers of the genus *Dadoxylon* (*Araucaroxylon*). The horizon of the fossil insects of St. John would thus be middle devonian.

In the finer shales of this series, the remains of plants are very perfectly preserved, the most delicate leaves having not only their outlines but also their nervature represented by films and lines of shining graphite, resembling pencil drawings on a dark gray ground. The insect wings are preserved in a similar manner.

The discovery of the insect remains is wholly due to the late Prof. C. F. Hartt, who, with the aid of other gentlemen, members of the Natural History Society of New Brunswick, removed by blasting large quantities of the richest fossiliferous beds and examined them with great care. The extreme rarity of these remains renders it probable that but for the large quantities of material examined by Professor Hartt, they would not have been found; while the extreme delicacy of the impressions would have prevented them from being observed except by a very careful collector scrutinizing every surface in the search for leaflets of ferns, preserved in such a way as to be visible only under the most favorable light. These unusually perfect explorations should be taken into the account in any comparisons made of the fossils of this locality with those of other places.

The following detailed section of the Little River Group, at the Fern Ledges, Lancaster, N. B., where the insects occur, is derived from Professor Hartt's paper in Bailey and Matthew's report before alluded to, and is substantially the same as given in my Acadian Geology.

Section at the "Fern Ledges." (*Order ascending.*)

Heavy beds of gray sandstone and flags (Dadoxylon sandstone). *Dadoxylon ouangondianum* Daws., *Calamites, etc.* Thickness, by estimation, 300 feet.

Under this head I have classed all the beds underlying the Plant-bed No. 1, which I am disposed to regard as the lowest of the rich plant-bearing layers, and the base of the Cordaite shales. These beds occupy the low ground lying between the ridge of the Bloomsbury group and the shore. They are covered by drift, and show themselves only in limited outcrops, and in the ledges on the shore. In the western part of the ledges they are thrown forward on the beach by a fault, forming a prominent mass of rock, in the summit of which a fine trunk of *Dadoxylon* is seen imbedded in the sandstone. Recent excavations made in these beds in quarrying stone for building purposes, in the eastern part of the locality, where the rocks are very much broken up by dislocations, have exposed numerous badly preserved impressions of large trunks of this tree.

PLANT-BED No. 1 . . . . . Thickness, 1 foot.

Black arenaceous shale, varying from a fissile sandstone to a semi-papyraceous shale, very fine-grained and very fissile, charged most richly with beautifully preserved remains of plants, among which are the following species:—

Calamites transitionis Goeppert. (*C. radiatus Br.*) Occasional, in large, erect specimens.—*Asterophyllites latifolia* Daws. Extremely abundant, often showing ten or twelve whorls of leaves, sometimes with many branches.—*A. acicularis* Daws. Also

very abundant.—*A. scutigera* Daws. The curious stems of this species, with their scale-armed nodes, occur abundantly in this bed.—*Sphenophyllum antiquum* Daws.—*Pecopteris obscura* Lesqx.—*Sphenopteris* sp.?—*Cardiocarpum cornutum* Daws. Rare.—*Psilophyton elegans* Daws. Occasional. I have never detected any trace of *Cordaites Robbii* Daws., in this bed. It is extremely common in the overlying strata.

Gray sandstones and flags, with occasional ill-preserved plants, *Calamites transitionis* Goeppt.—*Cordaites Robbii* Daws.—*Asterophyllites and Sternbergiae* . 2 feet 6 in.

Black arenaceous shales of the same character as those of Plant-bed No. 1, but without fossils, so far as I have examined . . . . . 11 inches.

Compact flaggy, gray sandstone, with badly preserved plant remains, *Calamites*, etc. . . . . 2 feet.

Very soft, dark, lead-colored shales, much slicken-sided and charged with fragments of plants. This bed is so soft that the action of the weather and the sea have everywhere denuded it to the level of the beach . . . . . 4 feet.

PLANT-BED No. 2 . . . . . 1 foot.

At the point where the section crosses the bed, and where I first discovered it, it consists of very compact and hard, light lead-coloured, slate-like, arenaceous shale; but the character of the shale varies much in its different exposures, being sometimes very soft and fissile, and of a very black colour. The following is the list of species which it affords:—

Calamites transitionis Goeppt. Occasionally; never in good specimens.—*C. cannaeformis* Brongn. Occasionally; never in good specimens.—*Asterophyllites acicularis* Daws. Rather rare.—*A. latifolia* Daws. Rather rare.—*A. longifolia* Brongn. (?). Rather rare.—*A. parvula* Daws. Whorls of a minute *Asterophyllites*, which may belong to this species, are not infrequent in this bed.—*Sporangites acuminata* Daws.—*Pinnularia dispalans* Daws. Abundant.—*Psilophyton elegans* Daws. Quite common, always in fragments, never in good specimens.—*P. glairum* Daws. Flattened stems, with a wavy woody axis traced in a brighter line of graphite, occur in this bed, but always in fragments.—*Cordaites Robbii* Daws. Extremely abundant, and very fine specimens may be obtained, especially from the upper part of the bed, and rarely specimens showing the base or the apex of the leaf.—*Cyclopteris obtusa* Lesqx. Occurs very abundantly in detached pinnules.—*C. varia* Daws. Rare.—*Neuropteris polymorpha* Daws. Extremely abundant, never in large fronds.—*Sphenopteris Hoeninghausii* Brongn. Quite abundant, often in fine fronds.—*S. marginata* Daws. Abundant, in fine fronds.—*S. Harttii* Daws. Very rare.—The original specimen came from this bed.—*Hymenophyllites Gersdorffii* Goeppt. Rather rare.—*H. obtusilobus* Goeppt. Rare.—*H. curtilobus* Daws.—*Alethopteris discrepans* Daws. Amongst all the abundance of plants afforded by Plant-bed No. 2, I have detected only one or two pinnules of this fern, which appears first in abundance in Plant-bed No. 3. It is afterwards one of the most common species.—*Pecopteris ingens* Daws. Very rare, only two or three fragments of pinnules having been found.—*Trichomanites* (?) Only a single specimen, probably, as Dawson has suggested, only the skeleton of a fern.—*Car-*

diocarpum cornutum Daws. Abundant, and very finely preserved, never attached —*C. obliquum* Daws. Quite abundant, also never attached.— *Trigonocarpum racemosum* Daws. Rare.—*Eurypterus pulicaris* Salter. The occurrence in Plant-bed No. 2 of this minute crustacean was first detected by my friend Mr. George Matthew. It is very rare, not more than four or five specimens having been found by Messrs. Matthew, Payne, and myself at the time of the description of the species by Salter. I have since that time succeeded in collecting nearly twice as many more, some of which appear to belong to a new species.—*Amphipeltis parudoxus* Salter. The specimen figured in Salter's paper was found by Professor Dawson and myself, in breaking a piece of shale in my cabinet, that came from this bed. Only one other specimen has since been obtained. It consists of two or more of the thoracic segments, and was collected by Mr. Lunn. It is in the collection of the Natural History Society of New Brunswick. In addition to the above species, this bed has afforded the following:—*Cyclopteris*, sp. nov—*Neuropteris*, sp. nov. A single specimen collected by Mr. Lunn.—*Sphenopteris*, sp. nov.—*Spirorbis erianus* Daws. The leaves of *Cordaites* in the upper part of the bed are as thickly covered with a little *Spirorbis* as are the fronds of the recent fucoids of the Ledges. The specimens are poorly preserved. — *Trilobites*. Mr. Payne collected a minute trilobite from from this bed, but it proved not determinable.—*Insect Remains!* In the summer of 1862, I discovered an organism in Plant-bed No. 2, which at the time I could make nothing of; but which I have since proved to be the wing of an insect. Several weeks after, I found in Plant-bed No. 8 an unequivocal insect's wing. This discovery was followed by that of others, my father, J. W. Hartt, finding another in this bed. [The insects of this bed are GEREPHEMERA SIMPLEX and XENONEURA ANTIQUORUM.]

Compact flaggy sandstone, quite barren . . . . . 5 feet 10 inches.

PLANT-BED No. 3 . . . . . 10 inches.

Black and lead-colored shales, quite compact in upper part, but in lower very crumbling, splitting irregularly, slicken-sided, often with polished surfaces, and traversed by thin quartz-veins. These shales are so soft that the sea and weather have everywhere denuded them to the level of the beach. There are now no exposures of the bed workable. The following are the fossils which occur in it:—

Calamites transitionis Goeppt. Occasionally. — *C. cannaeformis* Brongn. — *Asterophyllites latifolia* Daws. Very beautiful whorls of this plant are very common here, the whorls, though usually detached, being sometimes found united three or four together.—*Sporangites acuminata* Daws. Common.—*Pinnularia dispalans* Daws. Common.—*Psilophyton elegans* Daws. Occasionally.—*P.*(?) *glabrum* Daws. Occasionally.—*Cordaites Robbii* Daws. Extremely abundant, but not so well preserved as in Plant-bed No. 2. Leaves usually appear as polished bands of graphite, with venation obliterated.—*Cyclopteris obtusa* Lesqx. Not very abundant. —*Neuropteris polymorpha* Daws. In beautiful specimens, common.—*Sphenopteris marginata* Daws. Not common.—*S. Hoeninghausii* Brongn. Not common.—*Pecopteris* (*Alethopteris*) *discrepans* Daws. It was here that I first discovered this species. It occurs quite abundantly, but always in fragments.—*Cardiocarpum cornutum* Daws. Quite common.—*C. obliquum* Daws. Quite common.

Coarse sandstone, full of obscure casts of *Sternbergiae* and *Calamites* .	6 feet	6 inches.
Soft shale and fissile sandstone, with *Calamites*		3½ "
Sandstones	2 feet	3 "
Shale with obscure remains of plants		2½ "
Sandstones, barren, so far as examined	4 feet	10 "
Sandstone and shale, with a few *Calamites* and *Cordaites*		9 "
Sandstone and coarse shale, with obscure markings	5 feet	10 "
Light greenish, coarse shale, with fern-stems, *Cordaites*, and obscure markings, *Carpolites* (?)		7 "
Sandstones and coarse shales, with badly preserved vegetable remains	18 feet	9 "
PLANT-BED No. 4.	1 foot	0 "

Coarse shales, affording at the point where the line of section crosses it: —

Cordaites Robbii Daws.—*Calamites transitionis* Goeppt.—*Neuropteris polymorpha* Daws.—*Psilophyton glabrum* Daws.—*Pinnularia dispalans* Daws.

I have examined at two different points, in the eastern part of this locality, a bed which appears to correspond to this. It is characterized there by a very beautiful *Neuropteris*[1] (*N. Dawsoni* Hartt) with long linear lanceolate pinnules decurrent on the rachis, to which they form a broad wing. The pinnules are often four inches in length. This is one of the most beautiful ferns occurring at the locality. Several other new forms are associated with it. Among these is a magnificent *Cardiocarpum*, nearly two inches in diameter (*C. Baileyi* Daws.).

Sandstone with obscure markings	9 feet	6 inches.
PLANT-BED No. 5		6 inches.

Soft, fine-grained light-greenish shale.

Cordaites Robbii Daws. Extremely abundant. — *Calamites cannaeformis* Brongn. Found occasionally.—*Psilophyton* (?) *glabrum* Daws.—(?) *Asterophyllites acicularis* Daws. — *Alethopteris discrepans* Daws. Quite abundant.—*Sphenopteris marginata* Daws. Quite abundant.—*Pecopteris*, sp. nov. (?) — *Hymenophyllites* sp. (?)—*Neuropteris polymorpha* Daws. Very abundant—*Spirorbis* occurs in the bed, attached to the leaves of *Cordaites*. I have never detected it in any of the beds higher up.

Compact flaggy sandstones and coarse shales, with a few plants. . . .	8 feet.
PLANT-BED No. 6.	2 feet.

Fine-grained and light-coloured shale, with great abundance of *Cordaites Robbii*, and *Calamites transitionis*; above that a layer of coarse shale, with *Cordaites* and stems of plants badly preserved; then a layer of soft, very friable shale, with few fossils; and lastly, a layer of coarse shale of a greenish-gray colour, with: —

Alethopteris discrepans Daws. Abundant.—*Cordaites Robbii* Daws. Abundant.—*Calamites cannaeformis* Brongn.—*Neuropteris polymorpha* Daws.—*Cardiocarpum cornutum* Daws.—*Cardiocarpum obliquum* Daws.—*Pecopteris*, sp. nov. Occurs abundantly in some of the overlying beds.

Sandstones and coarse shales, with abundance of plant remains, principally *Cordaites* and *Calamites*	5 feet.

[1] This plant belongs to a new genus, subsequently named Megalopteris. Report on devonian plants of Canada, 1871.

PLANT-BED No. 7 . . . . . 2 feet.

This is one of the richest plant-beds of the section. The shales composing it vary much in character in different exposures. They are for the most part of a gray colour and compact, like a fine-grained sandstone, though they pass into a light brownish, very fissile, soft shale, and there are some layers of a very black colour.

Cordaites Robbii Daws. Very abundant, and in a beautiful state of preservation.—*Calamites transitionis* Goeppt. Not abundant as good specimens.—*C. cannaeformis* Brongn. Rare.—(?)*Asterophyllites acicularis* Daws. In very beautiful specimens, very common in certain thin layers. There are two or three other species, occurring also in the overlying beds, which appear to be new.—*Sporangites acuminata* Daws. Extremely plentiful.—*Pinnularia dispalans* Daws. Extremely plentiful.—(?) *Psilophyton elegans* Daws. I have obtained several specimens of a *Psilophyton* growing in tufts, and closely resembling this species.—*Neuropteris polymorpha* Daws. Occasional.—*Alethopteris discrepans* Daws. Abundant, and obtainable in good specimens.—*Cyclopteris obtusa* Lesqx. Occasional.—*Sphenopteris marginata* Daws.—*Hymenophyllites subfurcatus* Daws.—*Cardiocarpum cornutum* Daws. Quite abundant.—*C. obliquum* Daws. Quite abundant.—*C. Crampii* Hartt.—*Alethopteris Perleyi* Hartt.—*Sphenopteris pilosa* Daws.—Several other plants not yet determined.—*Insects.* A single insect's wing was obtained from this bed by my father and myself. [PLATEPHEMERA ANTIQUA.]

Compact sandstone and coarse shales (barren of fossils) . . . . . 3 feet.

PLANT-BED No. 8. . . . . 1 foot 10 inches.

Fine-grained, tough, but fissile sandstones, rather coarse shales, often of a greenish cast, and at the top a thin layer of very black shale very rich in plants. The middle portion does not contain so many plant remains, but the lower is as well stocked as the leaves of an herbarium. The following are the fossils I have collected from it:—

Cordaites Robbii Daws. As usual in great profusion, and in very fine specimens.—*Calamites transitionis* Goeppt. Occasional.—*C. cannaeformis* Brongn.—(?) *Asterophyllites acicularis* Daws. Quite common, together with one or two other species apparently new, which occur also in Bed 7.—*Annularia acuminata* Daws. Extremely common, especially in certain layers.—*Pinnularia dispalans* Daws. Abundant.—(?) *Lycopodites Matthewi* Daws. Rare.—*Cyclopteris obtusa* Lesqx.—*Cyclopteris*, sp. nov.—*Neuropteris polymorpha* Daws. Quite frequent in detached pinnules.—*Hymenophyllites subfurcatus* Daws. Very common.—*Alethopteris discrepans* Daws. This is the most abundant fern in this bed. It occurs usually in detached pinnules, though not unfrequently in considerable fronds.—*Alethopteris*. Besides the above, there are three or four other species, some of which occur also in Beds 6 and 7[1].—*Cardiocarpum cornutum* Daws. Not very common.—*C. obliquum* Daws. Also not very common.—*C. Crampii* Hartt. Quite common.—Several other species of plants not yet determined.—*Insects.* Two species, two specimens. One was obtained by my friend, Mr. James Hegan. [Three insects were obtained from the bed: HOMOTHETUS FOSSILIS, DYSCRITUS VETUSTUS and LITHENTOMUM HARTTII.]

[1] Probably the species afterwards described (Dr. Dawson's Report of 1871) as *Alethopteris Perleyi* Hartt, *Pecopteris serrulata* Hartt, and *Pecopteris preciosa* Hartt.

Sandstones and coarse shales, with badly preserved *Cordaites Robbii* Daws., *C. transitionis* Goeppt., and *Alethopteris discrepans* Daws.	26 feet.
Fine-grained, light-greenish shale, with obscure remains	1 foot.
Sandstone and shales, with *Calamites* and obscure markings	23 feet.
Total thickness of the beds embraced in this section . . .	440 feet, 11 inches.

XI. EXPLANATION OF PLATE.

Fig. 1. *Homothetus fossilis* (magn. ½). The dotted lines are conjectural; the break in the dotted line representing the outer border indicates the presumed amount of separation at that point to account for the bending of the outer piece of the wing.

Fig. 2. *The same* (1). With no parts restored.

Fig. 3. *Lithentomum Harttii* (1). The dotted lines show the presumed connection of the basal veins with the other fragment.

Fig. 4. *Dyscritus vetustus* (1).

Fig. 5. *Xenoneura antiquorum* (½). The dotted lines indicate the supposed course of the veins and border where they are not preserved. A portion of the base is shaded to show the exact appearance of the concentric ridges; this basal portion is mostly drawn from the same stone as fig. 7, but the small fragment unshaded, at the extremity of the anal vein, and the cross vein are drawn in from the reverse of fig. 5, shown in fig. 6; so also is the larger apical piece with part of the lower margin, these two parts being more complete on the reverse than on the obverse.

Figs. 6 and 7. *The same* (1). With no parts restored. The apical fragment of fig. 7 is not represented; it exists, but is not so complete as in fig. 6.

Figs. 8 and 8ª. *Gerephemera simplex* (1). The two independent lines at the extremity of the costal margin are inserted from a drawing made under the camera when only these lines and the outer margin with the tip of the veins were exposed; in working out the rest of the wing these were broken away, but are here restored. The arrow indicates the direction of 8ª, which represents the contour of the surface of the wing, the upper dotted extremity indicating the costal margin (shown to the left of the arrow), and the dots along its course the position of the veins it crosses.

Fig. 9. *Platephemera antiqua* (1). The faint line of dashes above the marginal vein represents the margin of the wing, indicated on the stone by a slight darkening of the surface. The dotted lines at base and at tip indicate the presumed form of the wing.

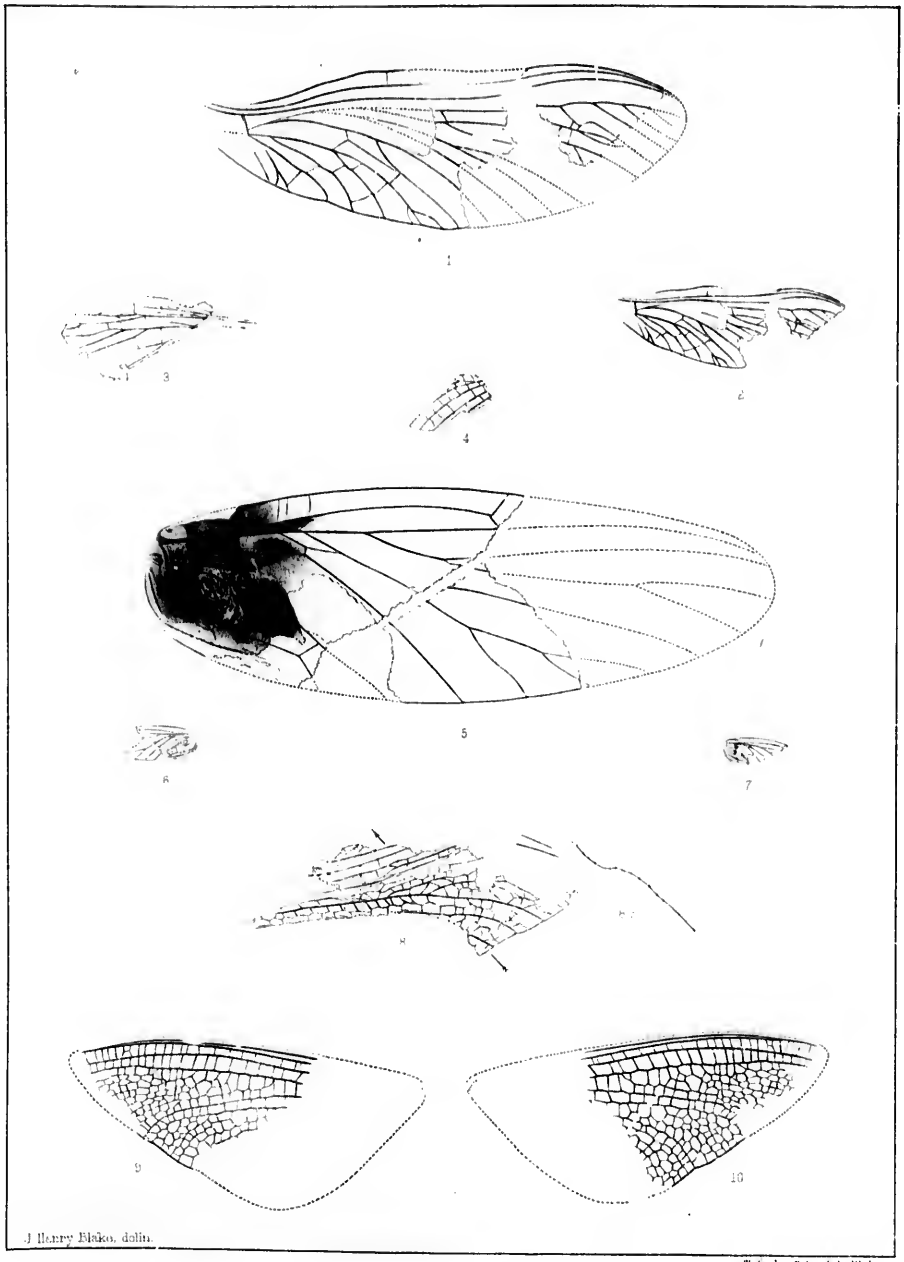
Fig. 10. *The same* (1). This figure, the reverse of fig. 9, is so placed in relation to the preceding as to indicate the probable expanse of wing of this insect; a fragment at the lower angle of this specimen is not preserved in fig. 9, which possesses a bit of the outer margin not found in this.

Figs. 1, 2, 4, 6, 8, 10 represent specimens preserved in the museum of the Natural History Society of St. John, N. B.

Figs. 3, 7, 9 represent specimens in the museum of the Boston Society of Natural History.

Fig. 5 is a composite drawing from the specimens in each museum. The Boston Society of Natural History possesses the reverse of a small portion of fig. 8; and the St. John Society the reverse of No. 3, neither of which are engraved.

The plate was executed by Messrs. Sinclair & Son of Philadelphia.



DEVONIAN INSECTS.